WINLOCK (Wm C.)

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FROM THE SMITHSONIAN REPORT FOR 1892.

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A review of the progress of astronomy for the years 1879 and 1880 was contributed by Prof. E. S. Holden to the Smithsonian Report for 1880, and reviews for each succeeding year were continued by him in the annual reports of the Institution up to 1884; the reviews for 1885 and 1886, and for 1887–'88 and 1889–'90 were prepared by the present writer, the publication since 1886 being biennial instead of annual. The arrangement of the review for 1891–'92 is essentially the same as in previous years and, in its compilation as hitherto, notes in recent journals have been freely drawn upon without specific citation.

It should be borne in mind that the review is intended for those having a general interest in astronomy rather than for the professional astronomer who has access to a large working library. To the latter the bibliography appended may be found convenient as a reference, and will supplement the text in giving a general idea of recent publications on any special subject. Many very important papers are of such a nature that they do not lend themselves readily to condensation for the purposes of such a summary as the present.

Within the last few years many new aids have been provided to facilitate reference to the constantly-increasing volume of the literature of the subject. The most comprehensive of these is to be found in the *Bulletin astronomique*, published under the auspices of the Paris Observatory and the able editorship of M. Tisserand. In addition to extensive critical reviews of important memoirs, there is a brief summary of the contributions to other astronomical periodicals, and the whole is made easy of reference by an admirable index (wherein most journals are defective) at the close of the year, which, in fact, to a large extent, supplies a bibliography of astronomy for the year. The *Journal of the British Astronomical Association* contains a summary of current periodical literature, the value of which to the members is abundantly vouched for. The *Publications of the Astronomical Society of the Pacific* contains a great number of admirable reviews or notes, and this department is receiving increased attention in *Astronomy and Astrophysics. The Observatory* has perhaps the most complete notes, without an attempt at a systematic summary of current

literature, to be found in English, while the excellent reviews in *Nature* and the more popular notes of the *Athenæum* need no special comment here. The *Astronomische Nachrichten* and the *Astronomical Journal* contain occasional notices of important works.

The "Notes on some points connected with the progress of astronomy during the past year" in the *Monthly Notices* of the Royal Astronomical Society have been increased in scope and fullness, and as the reviews in different branches of astronomy are furnished by specialists, these notes form a most valuable commentary on the year's work. The *Vierteljahrsschrift der astronomischen Gesellschaft* is, of course, the critical astronomical review, and is the recognized authority for summaries of cometary and planetary discoveries.

STELLAR SYSTEMS.

The Milky Way.—The independent researches of Prof. Pickering at the Harvard observatory and of Dr. Gill at the Cape of Good Hope have led to the conclusion that the stars of the Milky Way form a veritable sidereal system, separate and individual. This conclusion is entirely opposed to the views Sir William Herschel reached from his earliest observations (1785) which are still generally received by those who have not given much attention to this special question. Miss Clerke points out in the *Observatory* for September, 1891 (p. 302), that "the study of nebular distribution might alone, and long ago, have driven out of the field every form of 'projection theory' of the Milky Way. For it showed the great majority of gaseous nebulæ to be embraced within its circuit, and this alone amounted to a demonstration that a physical reality, and not simply a geometrical appearance, was in question."

A brief statement of the arguments of Prof. Pickering and of Dr. Gill is contained in a lecture by the latter delivered at the Royal Institution of Great Britain, May 29, 1891. Dr. Gill said:

I pass now to another recent result that is of great cosmical interest. The Cape photographic star-charting of the Southern Hemisphere has been already referred to. In comparing the existing eye estimates of magnitude by Dr. Gould with the photographic determinations of these magnitudes, both Prof. Kapteyn and myself have been greatly struck with a very considerable systematic discordance between the two. In the rich parts of the sky, that is, in the Milky Way, the stars are systematically photographically brighter by comparison with the eye observations than they are in the poorer part of the sky, and that not by any doubtful amount, but by half or three-fourths of a magnitude. One of two things was certain, either that the eye observations were wrong, or that the stars of the Milky Way are bluer or whiter than other stars. But Prof. Pickering, of Cambridge, America, has lately made a complete photographic review of the heavens and by placing a prism in front of the telescope he has made pictures of the whole sky. . . . He has discussed the various types of the spectra of the brighter stars, as thus revealed, according to their distribution in the

sky. He finds thus that the stars of the *Sirius* type occur chiefly in the Milky Way, whilst stars of other types are fairly divided over the sky.

Now stars of the *Sirius* type are very white stars, very rich relative to other stars in the rays which act most strongly on a photographic plate. Here then is the explanation of the results of our photographic star-charting, and of the discordance between the photographic and visual magnitudes in the Milky Way.

The results of the Cape charting further show that it is not alone to the brighter stars that this discordance extends, but it extends also, though in a rather less degree, to the fainter stars of the Milky Way. Therefore we may come to the very remarkable conclusion that the Milky Way is a thing apart; and that it has been developed perhaps in a different manner, or more probably at a different and probably later epoch from the rest of the sidereal universe.*

NEBULÆ.

In a paper by Prof. Keeler, communicated to the Royal Society by Dr. Huggins on March 19, 1891, the question of the position of the chief nebular line seems to be definitely settled. Prof. Keeler has not only made a series of sixteen complete measures, obtained on eleven nights, of the chief line in the spectrum of the Orion nebula, thus defining its apparent position when corrected for the earth's motion, as λ 5006.22 $\pm$ 0.014, but has supplemented these by ten measures of the green hydrogen line on seven nights. The latter show the nebula to be moving relatively to the solar system with a motion of $+$ 10.7 $\pm$ 1.0 miles per second, and oblige us to fix the true position of the chief line at λ 5005.93. The chief line is therefore 0.43 tenth meter more refrangible than the lower edge of the magnesium fluting, and as it has no resemblance to a fluting in appearance, and as flutings and lines of magnesium, which could not fail to appear at the same time with the fluting at λ 5006.36 are entirely absent from nebular spectra, the incorrectness of the view that the nebular line is the remnant of the magnesium fluting appears to be demonstrated.

Mr. Burnham has made a set of measures of the nebula in the Pleiades close to the star Merope. He remarks that it is one of the most singular and interesting objects in the heavens. With respect to its nearness to a bright naked-eye star (the distance between the centers is less than 40$''$) it is unique. There may be other examples, but certainly no other has ever been discovered, and this close association of a faint nebula and one of the prominent stars of the Pleiades is an interesting fact, whether such association is accidental or otherwise. The accurate measures made by Mr. Burnham and Mr. Barnard will enable this point to be ascertained when others shall have been made sometime hence, and it will be possible to determine by comparison whether the new nebula is drifting in space with Merope and the other stars of this famous group. We have, of course, many examples of large stars involved in widely diffused and extended nebulous masses,

*Publications of the Astronomical Society of the Pacific, 19.

but no instance has hitherto been known of a star bright enough to be visible to the naked eye having a small definite nebula within even several times the distance of this from Merope.

ASTRONOMICAL CONSTANTS.

The Constant of Aberration.—Prof. Comstock, of the Washburn Observatory, has been making careful trial of a modification of the method of determining the constant of aberration first suggested by M. Loewy. The essential feature of M. Loewy's method is the introduction of reflecting surfaces in front of the objective of a telescope, by means of which images of different portions of the heavens are simultaneously produced in the focal plane of the objective. By means of the micrometer the apparent distance between the images of two stars thus produced may be measured, and the angular distance between the stars determined from a simple relation involving the measured quantity and the angle included between the reflecting surfaces. It is obvious that great difficulties would attend the determination of this angle, and M. Loewy avoids these difficulties by measuring the distances of two pairs of stars and taking the difference of these distances, thus eliminating the angle between the mirrors. Prof. Comstock has found it advantageous to place before the objective three reflecting surfaces instead of two, making approximately equal angles among themselves, and to employ successively each pair of surfaces in measuring the distance between two given stars. If the normals to these surfaces all lie in the plane passing through the two stars and the earth, the mean of the three dihedral angles formed by the surfaces will be exactly 120°; and by taking the mean of the results furnished by the three pairs of surfaces the distance between a pair of stars may be determined independently of the angles between the mirrors. Prof. Comstock's provisional result for the constant of aberration is $20''.494 \pm 0''.017$.

MM. Loewy and Puiseux's work on the Constant of Aberration is summarized as follows in a communication to the *Comptes Rendus* for March 16, 1891.

1. Struve's value $20''.445$ is very near the truth. It would, in our opinion, be premature to alter it.
2. M. Fizeau's result, that reflection does not affect the behavior of rays with regard to aberration, is confirmed.
3. The new method for determining aberration can be regarded as satisfactory and definitive.

STAR CATALOGUES AND CHARTS.

The Star Catalogue of the Astronomische Gesellschaft.—The zone undertaken by the Harvard College Observatory +50° to +55° declination has been published as the fifth part of the great catalogue. The observations were made with the new meridian circle in the years 1870–'78 and 1883–'84, chiefly by Prof. W. A. Rogers, under whose direction

the reductions have also been made. The right ascensions were observed chronographically over eleven vertical wires, and the declinations also chronographically over an inclined wire, the circle being read by two microscopes. The probable error of an observation in 1870–'78 is $\pm 0.^s054$ in right ascension and $\pm 0''.55$ in declination, and is rather greater for stars fainter than the eighth magnitude than for brighter stars.

The fifth volume of the Annals of the Leyden observatory contains the second half of the zone observations between $+30°$ and $+35°$—embracing ten thousand observations.

The Paris Catalogue.—The second part of this work, containing the places of stars from 6^h to 12^h of right ascension, has recently been issued, the first part having been published in 1887. There are really three catalogues, the first comprising observations from 1837 to 1853 reduced to 1845.0; the second, those made from 1854 to 1867 reduced to 1860.0, and the third from 1868 to 1881 reduced to 1875.0. The stars are arranged in the order of right ascension at 1875.0. A valuable memoir on the proper motions of the stars contained in the catalogue has been prepared by Bossert.

Second Munich Catalogue.—A second catalogue, containing 13,200 stars for the epoch 1880.0 has been published under the direction of Prof. Seeliger supplementary to the larger catalogue recently issued. The stars are from the seventh to tenth magnitude within 25° of the equator, and were observed with the meridian circle during the years 1884 to 1888. The positions depend upon Auwers's Fundamental Catalogue.

Pulkowa Catalogue.—The Pulkowa catalogue of 5,634 stars for 1875 is deduced from observations made with the meridian circle during the years 1874–'80, and prepared for publication by Herr Romberg. The stars are of various classes, including many of the Struve double stars. A comparison is made with the places of several other catalogues.

Oeltzen's Catalogue.—A new editon of Oeltzen's catalogue of Argelander's southern zones, —15° to —31°, has been published by Prof. Weiss. The total number of stars is 18,276, the positions being given for 1850.0 with the amount of the precession necessary to bring them to 1875.0. The places of stars north of $-23°$ have been compared with Schönfeld's Southern Durchmusterung, and south of that limit with other catalogues, thereby eliminating a considerable number of errors from the original places.

Bœddicker's map of the Milky Way.—Dr. Bœddicker, of the Earl of Rosse's observatory at Birr Castle, has been at work since 1884 upon an elaborate map of the Milky Way from the North Pole to 10° south declination, and has at length finished this very laborious task. His plan has been to exhibit the ramifications of the Milky Way as it appears to the naked eye, a necessary first step to the knowledge of the structure of the sidereal universe. No optical help has been used.

STELLAR PARALLAX.

Prof. Pritchard has continued in Part IV of the publications of the Oxford University Observatory his work upon the photographic determination of stellar parallaxes. He has concluded "from actual and prolonged experience that an accuracy, amply sufficient in the present condition of astronomy, is secured by observations of each star made on twenty-five nights advantageously selected throughout the parallactic year, four exposures being usually made on each night."

The general result of the investigations of the parallax of thirty northern stars of the second magnitude is that the average parallax of a star of the second magnitude is 0.″056; and comparing with this the result of Drs. Gill and Elkin for the average parallax of fourteen first magnitude stars, viz, 0.″089 we see that there is distinct evidence that the brighter stars are nearer—though it should be borne in mind that the heliometer was used by Drs. Gill and Elkin, and the photographic method by Prof. Pritchard.

Following is a tabular statement of the Oxford results. Two results *a* and *b* are obtained, from two comparison stars; the probable error of each result is about ±0.″025:

Star.	Parallax.	
	a	*b*
	″	″
α Andromedæ	+0.0565	+0.0600
β Andromedæ	+.0610	+.0860
α Arietis	+.0880	+.0715
α Persei	+.0996	+.0738
β Persei	+.0642	+.0529
β Tauri	+.0730	+.0529
β Aurigæ	+.0591	+.0652
γ Geminorum	—.0135	—.0333
α Ursæ Majoris	+.0486	+.0436
β Ursæ Majoris	+.1177	+.0434
γ Ursæ Majoris	+.0768	+.1206
ε Ursæ Majoris	+.0832	+.0792
η Ursæ Majoris	—.0309	—.0628
β Leonis	+.0490	+.0087
β Ursæ Minoris	—.0200	+.0644
α Coronæ	—.0255	—.0493
γ Draconis	+.0625	+.0371
γ Cygni	+.1107	+.0931
ε Cygni	+.0927	+.1629
α Pegasi	+.0913	+.0719
ε Pegasi	+.0693	+.0919

Yale heliometer determinations of stellar parallax.—Dr. Elkin publishes the following preliminary results of his investigations of the parallaxes of the first magnitude stars in the northern hemisphere, proposing to continue his observations until he has secured one hun-

dred sets of measures of each of the ten stars—that number being required in his opinion to furnish parallaxes with probable errors not much above 0''.01:

Star.	Parallax.	Probable error.	No. of comparison stars.	No. of sets.
	"	"		
α Tauri	+0.101	±0.022	6	65
α Aurigæ	+0.095	0.021	5	51
α Orionis	+0.022	0.022	6	48
α Canis Minoris	+0.341	0.020	6	48
β Geminorum	+0.057	0.021	6	48
α Leonis	+0.089	0.026	10	43
α Bootis	+0.016	0.018	10	89
α Lyræ	+0.092	0.019	6	67
α Aquilæ	+0.214	0.023	10	46
α Cygni	—0.012	0.020	7	49

Determination of stellar parallax with a transit instrument.—Prof. Kapteyn has published a paper of much interest, upon the determination of relative stellar parallax by observations of the differences of right ascension between the selected star and neighboring comparison stars made with the transit instrument and chronograph. The comparison stars are selected of about the same declination as the star whose parallax is to be determined and symmetrically situated at slightly greater and less declinations. The differences of right ascension and of magnitude should be small. Special precautions are taken to eliminate all ordinary instrumental errors, particularly the error of clock rate, which has an important effect.

The following are the results published by Prof. Kapteyn. The probable error given in each case is not far from ±0.''03:

Star.	Parallax.	Star.	Parallax.
Bonn VII 81	+0.074	*Bonn VII* 104	+0.428
θ Ursæ Majoris	+ .052	105	+ .168
Bonn VII 85	+ .064	110	+ .030
20 Leo Minoris	+ .062	111	+ .016
Bonn VII 89	+ .176	112	+ .139
Bonn VII 94	+ .101	114	+ .038
Bonn VII 95	+ .038	119	+0.056
Lal. 20670	—0.011		

Parallax of δ Herculis.—Prof. Leavenworth has found a parallax of +0.''050 ±0.''014 from his own observations of this star; and from a series of observations published by Dembowski in his "Double Star Observations," +0.''030 ±0.''015.

Parallax of P Ursæ Majoris.—Dr. Franz finds from heliometer observations of this star at Königsberg from 1883 to 1890 a parallax of

+0.″10 with a probable error of 0.″01. As the annual proper motion is 3″, this parallax implies that the star is moving through space at a rate of 88 miles a second. Dr. Franz's result is considerably smaller than that obtained by Prof. Geelmuyden from transit observations, $\pi = 0.''27$ from differences of right ascension, and 0.″24 from differences of declination.

DOUBLE AND MULTIPLE STARS.

Gore's catalogue of binary stars.—Mr. Gore has compiled a useful catalogue of binary stars, for which orbits have been computed, giving, besides the elements, date of computation, etc., the magnitudes, colors, spectra, hypothetical parallax, observed parallax, relative brightness, and the constants A and B for use in Mr. Rambaut's method of computing the parallax from the orbital motion of the star in the line of sight. The more recent measures are given in a series of notes. The catalogue was originally communicated to the Royal Irish Academy, in June, 1890, and has been reprinted from the Proceedings.

Prof. Asaph Hall has made a further discussion of the relative motion of the two components of 61 Cygni and the question whether there is anything in the nature of a physical connection between the two. His conclusion is in favor of such connection, but although accurate observations of the mutual distances and angles of position date from 1825, and Prof. Hall includes in the discussion those made by himself up to 1891, it is not possible to reach any result with regard to the period of revolution, except that it is long.

Two lists of double stars discovered by Mr. Burnham, most of them with the 36-inch refractor, have appeared during 1892, bringing Mr. Burnham's double star discoveries up to 1264. Most of his measures are of the more difficult or interesting doubles, a measurement of 0″.1 being apparently quite a simple matter. Mr. Burnham has also published a number of investigations of double star orbits, and collected lists of measures.

Among lists of recently published measures of double stars should be mentioned the series of observations of 950 stars by Prof. Hall made from 1880 to 1891, with the 26-inch equatorial, of the United States Naval Observatory. With reference to the reduction and discussion of double star measures, Prof. Hall says: "The formulæ and corrections for personal equation of observation seem to me of doubtful utility, and a better way is to compare the measurements of the same star by different observers."

Discovery of double stars by means of their spectra.—In the review of astronomy for 1889–'90 attention was called to Prof. E. C. Pickering's discovery of the duplicity of ζ Ursæ Majoris and β Aurigæ through pecularities in their spectra which indicated differences in the motions of supposed components.

Prof. Pickering has more recently called attention to another interesting class of "invisible double stars," detected in a somewhat similar way by peculiarities in their spectra.

Of many double stars the brighter component is red or yellow, while the fainter component is green or blue. The spectroscope shows that this is due to the fact that the spectrum of the brighter component is of the second type, like our sun, while the spectrum of the fainter component is of the first type, traversed by strongly marked hydrogen lines. If the stars are near together the spectrum of the combined light resembles that of the sun, except that the hydrogen lines are all strong. Stars like β Cygni give such a spectrum, but the components are so far apart that the separation of their spectra is clearly shown. Several stars hitherto supposed to be single have been found whose spectrum is of the class described above, and the question arises whether they may not really be double with components so close that they can not be separated by ordinary means. In the detailed examination of the spectra of the brighter stars made by Miss Maury upon the Harvard photographs, stars occupying all intermediate grades from the first to the second type have been found, and it is difficult to determine whether there are really two spectra or merely changes in the spectrum of a single star due to physical causes. Upon the hypothesis of duplicity the hydrogen lines would probably show a periodic displacement, and in fact an examination of four photographs of the spectrum of Procyon does show a displacement of the lines which, if the phenomenon is due to the relative movement of a faint component, would seem to indicate that it is receding at the rate of 20 kilometers per second as compared with the bright component. The evidence of duplicity is not considered conclusive by Prof. Pickering, but, from an examination of ten other stars having a similar composite spectrum, five are well-known doubles, two have distant companions, leaving three, τ Persei, ζ Aurigæ, and δ Sagittarii, which it would seem from the above considerations may possibly be double.

VARIABLE STARS.

Algol.—Mr. Chandler has published the results of an interesting investigation of the variable star Algol, the periodicity of which appears to have been first discovered by Goodricke, at York, in 1782; and the explanation suggested by him of the periodic diminution of the brightness, that it is produced by the interposition of an opaque satellite, is now generally accepted, confirmed as it has recently been, by the investigations of Prof. Vogel. Mr. Chandler, after an elaborate investigation of the inequalities in the period, and also of the irregularity in the observed proper motion of Algol, has found that they may be satisfactorily accounted for by supposing that both Algol itself and the satellite which revolves round it in about 2 days 20.8 hours have a common revolution round a third, large, distant and opaque body, in a

period of about 130 years. The size of this orbit around the common center of gravity is about equal to that of Uranus around the sun. The plane of the orbit is inclined about 20° to our line of vision.

Several interesting cases of variability have been detected in the examination of the photographs of stellar spectra at the Harvard Observatory all showing the bright hydrogen lines; the change in brightness exceeding two magnitudes. The director of the Harvard Observatory has called for the coöperation of astronomers provided with telescopes of moderate power and not otherwise engaged, for the observation of a list of seventeen circumpolar variables of long period. The methods to be followed are set forth in a circular issued by the observatory, and accessible to all who are interested.

Nova Aurigæ—One of the most remarkable outbursts of "new stars" or "*novæ*" that has ever been recorded, occurred during the year 1892—a phenomenon of double interest in that it afforded an opportunity of study under improved astronomical apparatus.

On February 1, 1892, an anonymous postal card was received at the Royal Observatory, Edinburgh, announcing the presence of a new star in the constellation Auriga. It subsequently turned out that the discoverer was Dr. Thomas S. Anderson, an amateur astronomer living in Edinburgh, that the discovery had been made by the help of a star-atlas and a small pocket telescope, and that the star had been seen by him for some days previous to February 1; it was of about the fifth magnitude. In the first observations at Edinburgh it was found to be of a yellow tint and about the sixth magnitude, its position for 1892 being right ascension $5^h\ 25^m\ 3^s$; declination $+30°\ 21'$. Very fortunately systematic photographs of this region had been made for some time by Prof. Pickering at the Harvard Observatory, and the *Nova* was in fact found to have been photographed on thirteen plates taken between December 10, 1891, and January 20, 1892; while it does not appear upon a plate taken at Heidelberg on December 8, which shows stars down to the ninth magnitude. The outburst, at least above the ninth magnitude seems, therefore, to be pretty well fixed between December 8 and 10, 1892.

The Nova remained of the fourth or fifth magnitude till the end of February, then diminished somewhat rapidly, and by the end of March it was of the twelfth to fourteenth magnitude.

In August it was again easily visible. At the Lick observatory it was found to be of 10.5 magnitude on August 17, and 9.8 on August 19, and further fluctuations in brightness have occurred.

The spectrum was of the greatest interest. The chief characteristic was a brilliant array of bright, broad lines, attended by dark companions on the more refrangible sides. Numerous finer details were then added, dark lines crossing the broad, bright bands, and bright lines marking the dark companions.

Three lines have attracted more especial attention on account of their intimate connection with the suspected physical constitution of the star. "These are (1) the bright green line near b_4, and the less refrangible edge of the hydrocarbon band; (2) the line near the chief nebular line λ5006, and (3) the line near the pair of chromospheric lines λ4923 and λ4921. When the wave length of these lines, as quoted by the observers, are corrected for motion in the line of sight, and arranged in a table, the mean values come out very close to the wave lengths of three notable pairs of solar chromospheric lines; while magnesium and the hydrocarbons, as possible origins of line (1), are excluded by the absence from the lists of their inseparable companion lines and flutings.

Line (2) is claimed by four observers for the chief nebular line, but the weight of evidence seems to be against its nebular origin, and the outburst would seem to be a vast chromospheric disturbance, a view confirmed by Dr. Huggins' observation of the complete series of bright hydrogen lines in the ultra-violet—the same that Hale and Deslandres found in the solar chromosphere—but each with its dark companion.

An interesting article advocating the meteoric theory in explanation of the outburst is given by Prof. Lockyer in Volume 31 of the Nineteenth Century. The chromospheric theory of the near approach of two stars is given by Dr. Huggins in the June number, 1892, of the Fortnightly Review; Seeliger's modification of the meteoric theory is translated in Astronomy and Astrophysics for December, and a single-star chromospheric theory is offered by Sidgreaves in the October number of the Observatory.

STELLAR SPECTRA.

Draper catalogue of stellar spectra.—Volume 27 of the Harvard Annals contains a catalogue of the photographic spectra of more than ten thousand stars north of 25° south declination. The photographs were taken with an 8 inch Voigtländer lens, in front of which was placed a prism 8 inches square, with a refracting angle of 13°. The edge of this prism was so fixed that the star's light was dispersed in declination, the length of the spectrum being about a centimeter, and the star being allowed to trail slightly gave the spectrum a width of about a millimeter. Each plate covered 10° square and the spectra of all stars to the sixth magnitude were photographed. The spectra are divided, for convenience, into a large number of classes—A B C D indicating varieties of the first type; E to L, varieties of the second type; M, the third type; N, the fourth type; and O P Q spectra that do not resemble any of the preceding types. One of the most important features of the work is the method by which photographic magnitudes have been assigned. "The quantity measured in each case is the intensity of the spectrum in the vicinity of the G line. Accordingly, when stars having different spectra are compared, the results will not be the same as if the entire

light of the stars were measured. In the latter case, the results will differ with the color of the star, according to the method of measurement employed. This is a serious defect in the measures of the brightness of the stars in catalogues hitherto published. Since the present measures relate to rays of a single wave length, the same result should be obtained whether the method of comparison was by the photographic plate, the eye, or the thermopile."

The Draper catalogue gives the approximate positions of the stars for the year 1900, with their reference numbers in the Bonn Durchmusterung and the Harvard Photometry; their class of spectrum by letters; their photographic magnitudes and the differences of these from the magnitudes of the Durchmusterung, the Argentine General Catalogue and the Harvard Photometry. A well arranged table gives the details of the measures of magnitude on the various plates on which each star appears. The whole sky to 25° south declination was photographed twice with plates overlapping.

Volume 26, part 1, of the Harvard Annals gives additional details respecting the photographs, their measurement and reduction not conveniently included in the catalogue volume itself—a complete history of the Draper Memorial. A point brought out in the various matters discussed in this volume is the predominance of the first type spectra in the Milky Way elsewhere referred to, and the systematic undervaluing of the brightness of the Galactic stars by about one-fifth of a magnitude, by the "Durchmusterung" and "Uranometria Argentina" as compared with the Harvard photometric and photographic magnitudes.

A third volume is to follow devoted to the work of the 8-inch Draper telescope during the years 1889 and 1892 and to the discussion of stars of peculiar spectra.

A fifth type of stellar spectra.—Prof. E. C. Pickering has proposed to class in a "fifth type" stars whose spectra resemble those of the stars discovered by Wolf and Rayet. In general, his photographic survey has confirmed Secchi's fourfold division of stellar spectra, but many stars in Orion and the neighborhood differ considerably from the ordinary first type stars, the additional lines, instead of being faint as in Vega, being nearly as intense as the hydrogen lines, while two classes of objects, the planetary nebulæ and the stars, the spectra of which consist chiefly of bright lines, are left unprovided for. Prof. Pickering points out the close similarity of the grouping of the lines in these three classes and also the striking character of their distribution. While stars of the second and third types are about equally divided between the Milky Way and the regions remote from it, two thirds of the first-type star lie in or near the Milky Way and of the Orion stars four-fifths are found in the Milky Way.

A similar distribution of the planetary nebulæ has long been recognized, and Prof. Pickering shows that, of thirty three stars known as

the "Wolf Rayet," or as he suggests the "fifth type," every one lies within 10° of the Galactic equator, two thirds within 2° of it.

α Virginis.—Dr. Vogel's more recent observations of *α* Virginis at Potsdam accord with his earlier observations of the same star, showing that it is a close binary. The method of observation is quite interesting: The spectrum of the star and of terrestrial hydrogen are photographed together, and the displacement of the star lines on the photograph in the neighborhood of H γ is afterwards measured under a microscope. Stars with spectra of the second and third types give results of considerable accuracy, as the lines in such stars are numerous and sharp.

In the case of *α* Virginis the difficulties of observation were greater, the hydrogen lines being broad and diffuse, without any definite maximum of intensity, and there were no distinct lines in the vicinity of H γ to which the measurements could be referred. Dr. Vogel's measurements of twenty four photographs showed that the star lines were displaced alternately toward the upper and the lower end of the spectrum in a complete period of about four days, the maximum displacement toward the violet indicating a motion of the star toward the sun of 65.9 English miles, and that toward the red a receding motion of 47.5 miles per second. These observations are completely explained by supposing that *Spica* is a binary star having a period of one component about the other or the common center of gravity of about 4 days, (the orbital velocity of the larger component being 56.7 miles per second) and that the system is approaching the sun at the rate of 9.2 miles per second. On the assumption of a circular orbit, equal mass of the components, and the data given by observation, the mass of the system is 2.6 times that of the sun, and the distance between the components 6,260,000 miles.

In commenting upon Dr. Vogel's work Prof. Keeler says, "A wonderful picture of stellar motion is presented to our mind, and one to which the whole visible universe as revealed to us by our greatest telescopes offers no parallel. The spectacle of two great suns like our own, revolving around each other in only four days, at a distance no greater than that which separates the sixth satellite of Saturn from its primary, is one which the inadequacy of our optical powers will probably ever forbid us from actually beholding, but the indirect evidence that such extraordinary circumstances of motion exist is so complete that we must admit their reality."

β Aurigæ.—The Potsdam observations furnish a complete confirmation of Prof. Pickering's discovery of the duplicity of this star. The lines in the spectrum of the star appear double on every second day, and the component, in the line of sight, of the motion of the system can amount to nearly 150 miles a second, while the whole system has a motion relatively to the solar system of -4.03 miles; that is, a motion of this amount per second towards the solar system.

ζ Ursæ Majoris.—The duplicity of ζ Ursæ Majoris is not so satisfactorily confirmed. The maximum relative velocity of its two components seems to amount to about 100 miles per second.

α Bootis.—Mr. Keeler's recent measures upon the D line of the spectrum of *Arcturus* show that the velocity in the line of sight is not 80 kilometers per second, the value hitherto accepted, but 6.4 kilometers, which accords with the result obtained by Dr. Vogel. The mean of the measures at Potsdam from October 5, 1888, to May 23, 1890, is −7.1 ± 0.3 kilometers. The Lick observations from April 20, 1890, to August, 15, 1890, give −6.9 kilometers.

ASTRONOMICAL PHOTOGRAPHY.

The photographic chart of the sky.—The third* meeting of the permanent committee, appointed by the Astrophotographic Congress at Paris in 1887, was held at the Paris observatory from March 31 to April 4, 1892. Admiral Mouchez presided, the members of the committee pres, ent being Baillaud, Bakhuyzen, Beuf, Christie, Denza, Donner, Gill Henry (Paul), Henry (Prosper), Janssen, Kapteyn, Loewy, Mouchez, Pujazon, Rayet, Ricco, Tacchini and Trépied. The following astronomers were also present by invitation, Messrs. Abney, Andoyer, Belopolsky, Bouquet de la Grye, Cornu, Knobel, Gautier, Maturana, Plummer, Scheiner, Tisserand, and Wolf (C).

Drs. Bakhuyzen and Gill were elected vice-presidents and Prof. Kapteyn and Trépied secretaries.

From reports of progress made at different observatories the following notes indicate the advancement of the work:

Some delay had been experienced in securing the plates containing the reference lines or "*réseaux*," but provision was finally made to furnish them at an early day, as well as the photographic plates which it was necessary should be of a specially good quality of plate glass.

Algiers.—Instruments ready and only awaiting the plates and "*réseau.*"

Bordeaux.—Photographic installation has been ready for about a year; a number of experimental photographs have been taken and the work can commence as soon as a supply of plates is secured with the necessary "*réseau.*"

Cape of Good Hope.—Instrument practically ready.

Catania.—The instrument has been completed.

Helsingfors.—The instrument has been ready for several months and a considerable number of photographs have been taken.

La Plata.—Instrument ready.

Melbourne.—Instrument ready and a number of experimental plates have been secured.

Oxford.—Instrument ready and a number of plates submitted to the committee.

* The first meeting of the committee, for organization, etc., was held at the time of the Congress in April 1887, the second meeting or the first regular meeting for discussions, in September, 1889 (not 1890, as stated by a misprint in the review of Astronomy for 1889–'90).

Paris.—Instrument ready.

Potsdam.—Instrument ready and a number of plates submitted to the inspection of the committee.

Rio de Janeiro.—The photographic equatorial has been received and will be mounted at the new site of the observatory.

Rome (*Vatican*).—The instrument has been completed.

San Fernando.—The instruments are mounted and work can be begun as soon as the *réseau* is received.

Santiago.—The instrument is finished, but, owing to political disturbance in Chile it is impossible to fix a day for beginning the work.

Sydney.—Ready except for the "*réseau.*"

Tacubaya.—Instrument ready and a number of experimental plates submitted.

Toulouse.—The instrument was one of the first to be mounted; the "*réseau*" and photographic plates are only needed to begin the work.

Following is a summary of the resolutions adopted at this meeting:

(1) No change is made in the conditions of distance and magnitude of the stars that have formed the different parts of the catalogue of guide stars.

If, however, the guide star of the catalogue is not bright enough, a brighter one may be selected up to a distance of 10′ from the center of the plate.

(2) The "*réseau*" is to be photographed upon each plate by parallel rays of light. (To replace resolution 15 adopted at the meeting of 1889.)

(3) The orientation of the plates in zones above 65° declination will be arranged for the equinox of 1900; for other stars the parallel will be referred to the apparent equinox.

(4) The work decided upon by the congress of 1887 comprises two series of negatives made with different exposures. The committee, while urging special activity in securing plates of shorter exposure (negatives intended for the catalogue), would suggest that the best nights be also taken advantage of for plates of longer exposure (for the chart).

(5) Negatives from which the catalogue is to be formed will have two exposures for the same plate, one showing faintly the images of stars of the eleventh magnitude, the other with an exposure twice as long, the distance of the two images being 0.2 to 0.3 of a millimeter. (To replace resolution 23 of the meeting of 1889.)

(6) MM. Abney and Cornu are added to the committee on reproduction of the negatives.

(7) With reference to the production of the chart, purely photographic methods will be used, to the exclusion of all manual intervention.

(8) For the chart proper (long exposures) a series of negatives with single exposure will be taken, having an *even* degree of declination in the center of the plate. Further study will show whether it is desir-

able that in the second series (those with an *odd* degree at the center) there should be two or three exposures.

(9) To make it possible to pass uniformly and with certainty from Argelander's ninth magnitude to the eleventh magnitude desired for the negatives of the photographic catalogue there will be distributed among the observatories fine wire-gauze screens, absolutely identical, which, when placed over the object glass of the telescope will diminish the magnitude of a star by two units (adopting the coefficient 2.512 for the ratio between two consecutive magnitudes). Each observatory will from time to time make type negatives of certain specified regions.

(10) The committee suggests forty minutes as the length of exposure of the plates for the chart (the series of *even* declinations) under the ordinary atmospheric conditions of Paris, and with the Lumière plates used.

The committee on metallic screens will furnish the Messrs. Henry with a screen with which they will determine the time *t* for obtaining the eleventh magnitude stars of Argelander's scale. Then for each observatory provided with an identical screen, the ratio 40:*t* will be the factor by which to multiply the time of exposure necessary to secure satisfactory images of eleventh magnitude stars, in order to obtain the proper exposure for the chart plates.

(11) The questions of the number of reference stars for each negative for the catalogue, the choice of the stars, and the necessary steps to secure meridian observations are referred to a special committee, consisting of Messrs. Auwers, Bakhuyzon, Christie, Ellery, Gill, Kapteyn, and Loewy, with full powers.

(12) As soon as convenient each observer will prepare, or will have prepared by any observatory or bureau he may select—

(*a*) Measures of the position of each star on the catalogue referred by rectilinear coördinates to the nearest lines of the "*réseau*."

(*b*) Measures necessary for the determination of the stars' magnitudes.

The different observatories will publish the separate results of these measures and the Permanent Committee will undertake their reduction as soon as a sufficient number of meridian observations of the reference stars is at hand.

(13) The work upon the chart will commence at each observatory as soon as the metallic screen reducing the stars by two magnitudes is received, involving probably a delay of two months. Each observer may, however, begin before receiving the screen if he is confident that he can get all stars of the eleventh magnitude upon the catalogue plates.

(14) Without adopting a formal resolution, the committee would recommend as a separate and personal investigation, that a special series of negatives with long exposures be made of the region near the ecliptic.

The following distribution of the zones among the different observatories was definitively adopted in place of that previously published:

Observatories.	Latitude.		Zone.		No. of plates.
	°	′	°	°	
Greenwich	+51	29	+90 to	+65	1149
Rome	+41	54	+64	+55	1040
Catania	+37	30	+54	+47	1008
Helsingfors	+60	9	+46	+40	1008
Potsdam	+52	23	+39	+32	1232
Oxford	+51	46	+31	+25	1180
Paris	+48	50	+24	+18	1260
Bordeaux	+44	50	+17	+11	1260
Toulouse	+43	37	+10	+ 5	1080
Algiers	+36	48	+ 4	— 2	1260
San Fernando	+36	28	— 3	— 9	1260
Tacubaya	+19	24	—10	—16	1260
Santiago	—33	27	—17	—23	1260
La Plata	—34	35	—24	—31	1360
Rio de Janeiro	—22	54	—32	—40	1376
Cape of Good Hope	—33	56	—41	—51	1512
Sydney	—33	52	—52	—64	1400
Melbourne	—37	50	—65	—90	1149

(16) Every year before the end of January a report upon the progress of the work will be made to the bureau of the Permanent Committee.

(17) The thanks of the conference were voted for the courtesy of the Academy of Sciences in printing the Bulletin, and the hope was expressed that the different governments would provide the necessary means for the observations themselves and for the publication of the chart.

The sixth fasciculus of the Bulletin contains papers by Prof. Kapteyn and M. Sautier on the parallactic micrometer, and upon photographic magnitudes by Profs. Wolf and Dunér. The latter subject has also been discussed by Dr. Scheiner in the *Astronomische Nachrichten*, by Prof. Pritchard in the *Comptes Rendus*, and by Mr. Christie in the *Monthly Notices*.

Photographs of the Pleiades.—Rutherford's photographs of the Pleiades taken in 1872 and 1874 have been selected for measurement by Mr. Jacoby as offering an opportunity for comparing the accuracy of the photographs with that of heliometer and micrometer measures. Each plate contains two impressions of the cluster, both of which were measured. Mr. Jacoby's method consisted of measuring the position angle and distance from the star 24 *p*, and he finds the probable error of the mean of the twenty exposures to be about ± 0.″03 in each element.

A comparison between these photographic places and the places resulting from the Yale and Königsberg heliometers shows that the photographs are fully entitled to be taken into consideration in making a study of the proper motions or in forming a definitive catalogue of the group.

Dr. Max Wolf, of Heidelberg, with a portrait lens of 2½ inches aperture, has not only discovered new nebulæ on his long exposure photographs, but new minor planets; several meteors which crossed the field left perfectly distinct records.

COMETS.

In a series of papers in the *Bulletin Astronomique* M. Schulhof has developed in an interesting way the relations existing between the elements of a comet's orbit before and after it suffers perturbation by a planet. That the periodic comets of our system have been captured through the perturbing action of planets appears established; and Mercury has four comets assigned to it, Venus seven, the Earth ten, Mars four, Jupiter twenty-three, Saturn nine, Uranus eight, Neptune five, and a further group of comets appears to give a feeble indication of an ultra-Neptunian planet at a distance from the sun of about seventy times that of the earth.

The search for new comets has been systematized by the cometary section of the British Astronomical Association under the direction of Mr. W. F. Denning. The aims of this section are to secure observations of comets, to discover new comets and nebulæ, to record telescopic meteors, etc. It is intended to sweep the sky regularly for new comets, a definite region being assigned to each observer according to convenience and choice.

The following notes, relating chiefly to the comets of 1891 and 1892, will complete the list of comets published in these "Reports of Progress," from 1883 to 1892. It is hardly necessary to remark that the most complete and authoritative annual summary of cometary phenomena is that published by Dr. Kreutz in the *Vierteljahrsschrift der Astronomischen Gesellschaft.*

The arrangement adopted below is the order of perihelion passage, except in the case of well-known periodic comets, such as Encke's, Winnecke's, etc., which are arranged alphabetically by their recognized names. The table of elements appended is to be regarded as only approximate, but is sufficient to furnish an idea of the general form and position of the orbit.

Comet Encke: Comet 1891, III. The return of Encke's well known periodic comet; first found by Barnard, from the ephemeris, on August 1, 1891. It was then exceedingly faint, but in September it had increased to a nebulous mass of about the sixth to seventh magnitude. The comet was unfavorably situated for observation after the end of September, the last observation reported being October 11. It is noteworthy that its path at this return was almost the same as in the return of 1858, and a comparison of the brightness on these two occasions would seem to indicate that it has not undergone any material change in physical condition during the interval.

Comet Tempel.—Tempel's first periodic comet, and of rather unusual interest, was unfortunately missed at its return in 1892, being unfavorably situated for observation.

Comet Tempel$_3$-Swift: —Comet 1891 V. This periodic comet returns to the sun once in every five and a half years, but un-

der conditions alternately favorable and unfavorable for observation. It was originally discovered by Tempel in 1869, was picked up again in 1880 by Swift, and again upon this return by Barnard. At its intermediate returns in 1875 and 1885 it was so situated with reference to the earth and sun as to have been entirely invisible. A very carefully prepared ephemeris by Bossert, taking account of the perturbations from 1880, enabled Barnard to find the comet on September 27, 1891, and it was independently found by Denning at Bristol on September 30. It was described as a faint, shapeless nebulosity, with slight condensation about the center, but even at its brightest, towards the end of November, it was a difficult object for precise observation, a fact all the more to be regretted as its position would render it of especial value for the determination of the distance of the sun.

Comet Winnecke: Comet 1892 IV. Winnecke's well-known periodic comet was picked up at this return, through the help of von Haerdtl's ephemeris, by Spitaler at Vienna on March 18, 1892; it was then an exceedingly faint and small nebulous mass with stellar nucleus of the sixteenth magnitude. It increased in brightness towards perihelion (on June 30), and after perihelion was observed in the southern hemisphere till the end of September.

Comet 1886 IV,* which was discovered by Brooks on May 22, 1886, was expected to make its first return to perihelion in the latter part of 1892, but was not found. The orbit is somewhat uncertain.

Comet 1889 V.—To quote from the first of a series of masterly papers on the orbit published by Mr. Chandler in the Astronomical Journal: "The vicissitudes in the history of this comet give it an interest exceeded, perhaps, by no other in astronomical annals; and the settlement of the problems connected therewith promises to illuminate our knowledge of cometary mechanics in various important particulars.

While the manner in which the comet became separated into several parts, by its encounter with Jupiter in 1886, may possibly require for its precise exposition the observations which will be obtained at the next appearance in 1896, we may hope for an approximate answer in the careful discussion of those made in 1889 alone. . .

To begin with, it is necessary to notice some of the physical phenomena presented by the companions. The notation used will be the letters assigned by Barnard, *B C D* and *E* in order of the distances from the main comet *A*. As is known, *B* and *C* were detected by him on August 1, with the 12-inch, *D* and *E* on August 4, with the 36 inch. It is desirable to remark here that the reason for their not having been discovered in the previous month, on July 8, 9 and 10, can not have been superposition by perspective, at least in the case of *C* and the more distant companions; for the orbit of *C* . . . shows that

* See Smithsonian Report 1887, p. 123.

such superposition occurred two months previous to discovery of *A* by Brooks, and gives for July 8 a distance of 190″ at 62°.5 position angle. That the companions were not seen in July, may be naturally ascribed to interference of moonlight up to about July 20, and after that either to the fact that the attention of observers was not sufficiently directed to the phenomenon, or to the fact that the objects had not yet become bright enough to be easily discernible. We have the evidence of Spitaler that on July 30 and 31 nothing abnormal was noticed with the 27 inch; the slight elongation on these dates, seen by him in *A* having no relation to the matter in hand. Two nights after, at the time of discovery, Barnard estimated the brightness of *C* at about one-fifth that of *A*. It then gradually increased in brilliancy, also becoming less diffused and developing a strong condensation and nucleus, until at the end of August it was actually brighter than *A* although only one-third its size. In early September it was about equal in brightness to *A* but from the middle of that month faded, and became larger and more diffuse until it disappeared, late in November. The faint nucleus of *B*, in the beginning appears to have been a little brighter than that of *C*, and its coma smaller and less diffused. About the middle of August it had grown to be larger and fainter than at first, later more rapidly so, being excessively difficult to see or measure in the first few days of September, and invisible immediately thereafter. *D* and *E* were measured only on the night of discovery, and were seen only at rare intervals until the last time on August 29.

Such, briefly described, are the main features as to brightness and visibility of these objects. I beg courteously to dissent from the view which has been confidently expressed, that the diffusion and disappearance of *B*, while it was theoretically increasing in brightness, indicate 'that it actually dissipated itself into space and absolutely ceased to exist, if indeed it were not absorbed into the main comet.' Such a conclusion is inherently improbable, unwarranted by any knowledge we possess as to the process of cometary light development, and contradicted by inferences drawn from other cases, of which only the most analagous need be cited, namely, that of the two nuclei of Biela's comet, the capricious action of which affords a strict counterpart to the present instance. It will be recollected that fitful alternations of visibility occurred in 1846, and especially in 1852, when they repeated themselves almost from day to day. The two companions were not habitually seen at the same time, but sometimes one, sometimes the other; so that observers could not tell which they were looking at, without comparison with the ephemeris. Thus, in the space of one week, for example, 1852, September 15 to 22, both nuclei were visible, then only the southern, then only the northern, then both together; again only the southern, and, finally, only the northern, on successive nights, respectively.

It may be added that there appears to be little reason for interpreting these remarkable variations of brilliancy as standing in any relation of effect with cause which produced the disruption, either in Bie-

la's comet or in 1889 V; but much more for supposing that similar behavior may be common, in greater or less degree, escaping attention ordinarily from the difficulty of photometric comparisons in the case of isolated comets, but easily attracting the eye, by contrast, when two objects nearly alike are in the same field."

Mr. Chandler's discussion of the orbits of these companions establishes the important proposition that the force which led to the separation of the components A and C, whatever its nature, operated in the plane of the comet's orbit, and produced no change in that plane or in the form of the conic section, but only in its size, and in the direction of its major axis. With reference to the identity with Lexell's comet, Mr. Chandler sees no sufficient reason in the differences of the period of revolution (28.18 years, according to Mr. Poor, instead of 27 years) to reject the supposition; it is necessary to carry the computation of the perturbations a little farther back.

Comet 1890 II.—The last observation in 1891 was on May 29 by Spitaler at Vienna; but it was again favorably situated in January and February, 1892, and was observed at Nice up to February 4, 1892.

Comet 1891 I:
=Comet *a* 1891.

Discovered by Barnard at the Lick Observatory on March 29, 1891, and independently by Denning at Bristol on March 30. It was quite bright, tenth to eleventh magnitude, about 1′ in diameter and with a tail 10′ to 30′ long. At the time of discovery its position was $\alpha = 15^h$, $\delta = +45^\circ$; it moved rapidly south, increasing in brilliancy, and was followed after perihelion till July, the last observation having apparently been obtained at Cordoba on July 9, 1891.

Comet 1891 II:
=Comet *b* 1891.
=Comet 1884 III.
=Wolf's comet.

First detected upon this its second appearance by Spitaler, of Vienna, on May 1, 1891, and by Barnard on May 3, its position agreeing closely with the ephemeris. It was at first small and faint, but in August it had a bright nucleus of the eleventh magnitude, with coma of 3′ to 4′ diameter; it decreased in brightness again after the middle of October, but was observed till March 31, 1892. Early in September the comet passed over the group of the Pleiades, and the circumstance was taken advantage of by a number of astronomers to determine whether the light from these stars underwent any refraction in passing through the material of which the comet was composed. The results obtained were for the most part negative, with the possible exception of an observation by Burnham on September 2, when the difference of declination between 21 and 22 Asterope seemed to show some change as the comet passed over them.

The orbit of this comet may bring it at times close to Jupiter, and indeed the perturbations by that planet in 1875 were so great that an altogether new orbit resulted. The period of revolution is about six and three-fourths years.

Comet 1891 III:
=Comet *c* 1891.
=Encke's comet.

See comet Encke.

Comet 1891 IV:
=Comet *e* 1891.

A telescopic comet of the twelfth magnitude, discovered by Barnard at the Lick Observatory on October 2, 1891. At the time of discovery it was in the constellation Argo; it moved farther south and was not seen at all in the northern hemisphere except at the Lick Observatory, where it was followed up to October 9; in the southern hemisphere it does not seem to have been followed beyond October 11.

Comet 1891 V:
=Comet Tempel$_3$-Swift.
=Comet 1869 III.
=Comet 1880 IV.
=Comet *d* 1891.

See comet Temple$_3$-Swift.

Comet 1892 I:
=Comet *a* 1892.

Discovered by Swift on March 6, 1892, at 17^h Rochester mean time, or 5 o'clock on the morning of March 7, in 30° south declination; the brightest comet seen in the northern hemisphere since the great September comet of 1882. At the time of its greatest brilliancy, which was at perihelion, April 6, it was as bright as a star of the third or fourth magnitude, with a bright, round head and nucleus of 10″ to 15″ diameter. The tail, on the other hand, was exceedingly faint, and was variously estimated at from 1° to 20° in length. Barnard reported it on April 3 as double. The photographs of the tail were of unusual interest, especially those taken in March at Sydney and in April at Mount Hamilton. On the morning of April 5 a photograph, made by Barnard at Mount Hamilton with a 6 inch lens, showed three main branches to the tail, each being separated into several others, so that in all at least a dozen could be counted. At a distance of two degrees from the head, along the northern side of the middle tail, there was a sudden bend southward. On the 7th "the southern component, which was the brightest on the 5th, had become diffused and fainter, while the middle tail was very bright and broad; its southern side, which was the best defined, was wavy in numerous places, the tail appearing as if disturbing currents were flowing at right angles to it. At 42′ from the head the tail made an abrupt bend towards the south, as if its current was deflected by some obstacle. In the densest portion of the tail, at the point of deflection, is a couple of dark holes similar to these seen in some of the nebulæ."

The comet was visible to the naked eye till the beginning of June, and was still under observation with the telescope at the close of the year.

The spectrum as observed by Konkoly on April 1 and 2 consisted of a continuous spectrum and five bright lines, while Campbell, at the

Lick Observatory, whose observations extend from April 5 to June 13, saw, in addition to the continuous spectrum, the three usual cometary bands, the less refrangible sides of these bands being sharply defined and the middle one, in fact, terminated by a very bright line.

The orbit of the comet is undoubtedly elliptic, belonging to the interesting group of comets with a period of about two thousand years. During this appearance, as it was for a considerable time in the neighborhood of Jupiter, its path may be considerably changed.

Comet 1892 II: Comet *c* 1892. Discovered by Denning, at Bristol, on March 18, 1892, in 23^h right ascension, and 59° north declination; it was then at its maximum brightness, small, round, with central condensation of from eleventh to twelfth magnitude, and no tail. It remained small and inconspicuous, but was under observation for several months. The orbit is parabolic, without specially interesting peculiarity.

Comet 1892 III: =Comet *f* 1892. =Holmes's comet. Discovered by Mr. E. Holmes, at London, on November 6, 1892, near the great Andromeda nebula, and also independently on November 9, by Davidson, at Mackay, Queensland—a round nebulous mass 5′ in diameter with a central condensation, but no tail; the suspicion that it was a return of Biela's comet was shown to be unfounded as soon as sufficient observations were available for a determination of its orbit, though the orbit proved to be elliptic and of short period. A short faint tail was seen soon after discovery, and upon a photograph taken by Barnard, on November 10, it can be followed for half a degree, while about a degree from the head and beyond the tail there is a diffused nebulous object, apparently belonging to the comet, and this connection seems substantiated by Campbell's spectroscopic observations.

The comet was visible to the naked eye to the end of November and in telescopes of medium power during the first part of December, and then diminished very rapidly in brightness, not following at all the computed scale of brilliancy, but showing a remarkable and inexplicable outburst about the 16th of January, 1893. The spectrum was also peculiar in that it seemed to be purely continuous.

According to the elements computed by Schulhof the comet passed perihelion on June 13, 1892, and its period is 6.9 years; the orbit seems to lie entirely within that of Jupiter, the nearest possible approach of the two being 0.4, (the mean distance of the earth from the sun being 1,) but since 1861 the two bodies do not seem to have been very close at any time. The small eccentricity, not far from that of Tempel's first periodic comet, brings it quite near to the upper limits of the eccentricity of the asteroid orbits. But with such a short period, as it can not have experienced great perturbations since 1861, the reason for its never having been seen at a previous return, is a mystery which seems to be connected in some way with the very great and abnormal variation

in brightness actually detected while under observations, the cause of which still lies beyond us in the unknown characteristics of cometary material.

Comet 1892 IV: =Comet *b* 1892. =Winnecke's comet. Found by Spitaler, at Vienna, on March 18, 1892. *See* Comet Winnecke.

Comet 1892 V: Comet *e* 1892. Especial interest attaches to this comet, as it is the first discovered by photography, if we except the single case of the "Tewfik comet," shown near the sun on a plate exposed during the total eclipse of May 17, 1882. The present comet was detected as a suspicious looking object upon a plate exposed near α Aquila on October 12, 1892, by Barnard. On the following evening the cometary character of the object was confirmed by the 12-inch refractor. It was faint, 1′ in diameter, and from twelfth to thirteenth magnitude, somewhat condensed toward the center. It changed but little in appearance and was last seen in December.

Dr. Krueger's elements give a period of revolution of only 6.3 years and show a remarkable resemblance to those of Wolf's comet—so great, in fact, as to suggest a common origin for the two, as in the case of Biela's comet and Brooks's comet, 1889 V.

Comet 1892 VI: Comet *d* 1892. Discovered on August 28, 1892, in the constellation Gemini, by Brooks, a quite bright, round nebula, with distinct nucleus and short faint tail; it was visible to the naked eye in November, and the tail could be followed, upon a photographic plate, November 26th, for 5°; after the middle of December the comet was observable only in the southern hemisphere.

The spectroscope showed a continuous spectrum with the three usual cometary bands.

Comet 1893 I: Comet *g* 1892. This comet was also discovered by Brooks, at Geneva, N. Y., in the constellation Bootes, on the morning of November 19, 1892; it was then quite bright for a telescopic comet, but showed no tail, while its increase in brightness and northerly motion made it an easy object for observation during the rest of the year.

In chronicling the comets of the year 1892 mention should be made of a suspicious object detected by Prof. M. Wolf upon photographic plates exposed on March 19 and 20, 1892. It could not be found upon a photograph of March 22 nor in a later search with the great Vienna refractor.

The announcement of a comet discovered by Freeman on November 26, 1892, proved to be erroneous.

A comet announced by Swift on December 23, 1889, has been identi-

fied by Dreyer with a nebula discovered by Herschel, and is, therefore, to be stricken from the list of lost comets.

Approximate elements of the comets of 1891 and 1892.

Designation.	Perihelion = T (Greenwich mean time).	Ω		ω		ι		q	e
		°	′	°	′	°	′		
1891 I	1891, Apr. 27.56	193	56	178	48	120	31	0.397	....
II	1891, Sept. 3.46	206	22	172	48	25	15	1.592	0.557
III	1891, Oct. 17.98	334	41	183	57	12	55	0.340	0.847
IV	1891, Nov. 12.94	217	39	268	33	77	43	0.977	....
V	1891, Nov. 17.34	296	31	106	43	5	23	1.087	0.653
1892 I	1892, Apr. 6.69	240	54	24	31	38	42	1.027	0.999
II	1892, May 11.22	253	26	129	19	89	42	1.971	....
III	1892, June 13.27	331	42	14	11	20	47	2.140	0.410
IV	1892, June 30.89	104	5	172	6	14	32	0.886	0.726
V	1892, Dec. 11.05	206	39	170	14	31	12	1.429	0.581
VI	1892, Dec. 28.09	264	28	252	41	24	48	0.976	....
1893 I	1893, Jan. 6.52	185	39	85	14	143	52	1.195	....

Designation.	Discoverer.	Date of discovery.	Synonym.	Remarks.
		1891		
1891 I	Barnard	Mar. 29	1891 *a*	
II	Spitaler	May 1	1891 *b*	Wolf's comet. Period 6.8 years.
III	Barnard	Aug. 1	1891 *c*	Encke's comet. Period 3½ years.
IV	Barnard	Oct. 2	1891 *e*	
V	Barnard	Sept. 27	1891 *d*	Tempel$_3$-Swift. Period 5.5 years.
		1892		
1892 I	Swift	Mar. 7	1892 *a*	
II	Denning	Mar. 18	1892 *c*	
III	Holmes	Nov. 6	1892 *f*	Period 6.9 years.
IV	Spitaler	Mar. 18	1892 *b*	Winnecke's comet. Period 5¾ years.
V	Barnard	Oct. 12	1892 *e*	Period 6.3 years.
VI	Brooks	Aug. 28	1892 *d*	
1893.				
I	Brooks	Nov. 19	1892 *g*	

METEORS.

A fine shower of meteors, radiating from the neighborhood of γ Andromedæ, was seen in the United States and Canada on the night of the 23d of November, 1892. There seems to be no doubt that it was a part of the great stream connected with Biela's comet, which was encountered on the 28th of November, 1872 and 1885. On these two occasions the earth probably passed through the main swarm, while in 1892 it passed some days earlier through an associated branch of it. From a comparison of the positions of the comet and of the dates of the meteoric showers in 1798, 1838, and 1872 Prof. Newton was long ago led to conclude "that a long, extended group of meteor particles must accompany the comet in its periodical revolution, preceding it to

a distance of 300,000,000 miles in front, and following it to a length of 200,000,000 miles in the rear of its actual position, or occupying, if there is no reason to suppose the elongated meteor current discontinuous, fully 500,000,000 miles in its observed length along the comet's path."

SOLAR SYSTEM.

Motion of the solar system.—Prof. Porter has discussed the proper motions of 1,340 stars contained in publication 12 of the Cincinnati observatory. Adopting Dr. Schönfeld's method of dividing the stars into four groups, according to the magnitude of their proper motions, he has confirmed Dr. Stumpe's result that the proper motion of a star is an index of its distance from us. The mean position of the "sun's way" from his figures is 281°.2 right ascension and +40°.7 declination.

Dr. Vogel has also published the results of an inquiry on this subject based on the measured velocities of stars in the line of sight. The motion of fifty-one stars has been determined at Potsdam, and the probable error in the measurement is below 1.16 geographical miles, but the resulting value of the apex of motion, though the observations have been discussed in various ways, is not in very satisfactory accord with other investigations. If the stellar motions be treated either with equal weights, or weights approximately proportional to those assigned by Dr. Vogel in his catalogue of proper motions, the coordinates of the apex are 206°.1 ± 12°.0 in right ascension, and +45°.9 ± 9°.2 in declination, with a velocity of 11.60 ± 1.85 geographical miles.

SUN.

Diameter of the sun.—A large number of heliometer measures of the diameters of the sun and Venus made by the German transit of Venus parties in 1874 and 1882, incidental to the more important determination of the solar parallax, have been discussed by Dr. Auwers, who finds for the mean result of the sun's diameter (thirty-one observers) 1,919″.3, which differs considerably from that adopted in the various ephemerides: the Berlin Jahrbuch, for instance, uses 1,922″.4, the Connaissance des Temps and British Nautical Almanac 1,923″.6, and the American Ephemeris 1,924″.0. Dr. Auwers remarks that if the value he finds is affected by irradiation it can only be too large, while the adopted diameters are larger still. He announces that a change will be made in the value used by the Berlin Jahrbuch in the volume for 1895.

Temperature of the sun.—The numerous attempts that have been made to determine the temperature of the sun have led to the most discordant results, the figures varying from 1,500° to 5,000,000°. The method employed, however, has always been the same (that of Pouil-

let), and the experimental determinations have been sufficiently concordant in themselves, the divergencies arising from the different laws adopted to connect the radiation of incandescent bodies with their temperature. Newton's law, which holds only for an interval of a few degrees, gives for the temperature of the sun millions of degrees. Dulong's, which is only exact over a range of 150° at most, gives 1,500°. Rosetti's law, established by experiments made between 0° and 300°, gives 10,000°. A more recent series of experiments has been made by M. H. Le Chatelier, and is published in the *Comptes Rendus* for March 28, 1892, in which the temperatures employed cover a range of 1,100° (700° to 1,800°). The "effective" temperature that he finds for the sun is 7,600°, which he thinks may be subject to an uncertainty, on account of errors which may effect the law of radiation, not greater than 1,000°, the "effective" temperature being that temperature which a body of emissive power equal to unity must have in order to send us radiations of the same intensity as the sun. The actual temperature of the photosphere is higher, for a part of its radiations are absorbed by the less highly heated solar atmosphere, and perhaps also (although this seems hardly probable) because the emissive power of the sun may be less than unity.

Solar activity in 1892.—The development of the solar activity during 1892 was no less marked with regard to prominences than with regard to sun spots. On April 6 Trouvelot reported an arched prominence extending some 90,000 miles along the limb of the sun and attaining a height of over 57,500 miles. Two days later an enormous protuberance rose to a height of 71,970 miles, extending in a little over half an hour to 105,550, and a week later another extending over 255,000 miles along the circumference.

The great sun spot group of 1892.—It appears that the original formation of the group took place on the farther side of the sun, and it first came under observation on November 15, 1891, when it was seen as a spot of considerable size close to the east limb. On November 16 the group consisted of three spots, and by November 18 it had assumed the appearance so typical of the more important disturbances, of a long procession of spots of various sizes, the spot in the van and that in the rear being the largest. During the December appearance (December 12–24) it was throughout one well defined circular spot.

One spot, roughly circular in shape, alone appeared on January 7. It is not quite clear whether it represented the principal group of the November appearance or the little group which formed in advance of it and which became prominent during December. It seemed to occupy a position nearly midway between the two, though the two are practically to be regarded as one disturbance.

Before its appearance at the east limb on March 4 a great change had taken place. The group, which on February 13 had covered more

than 3,000 millionths of the sun's visible hemisphere, did not cover one-fifteenth of that area on March 5, though it revived somewhat before it was last seen at the west limb on March 17, but did not survive to make a sixth appearance at the east limb on March 31 or April 1.

According to Mr. Maunder the great spot, the largest on record at Greenwich, was 92,000 miles long and 62,000 miles broad, while the entire group of which it formed the principal part was 162,000 miles long and 75,000 broad. The area of the spot on February 13, 1892, was 2,940 million square miles, and the whole group 3,530 million square miles. This is about eighteen times the area of the earth, and seventy globes as large as ours could have lain side by side in the immense hollow. Mr. Maunder thinks that the effect upon the weather of a spot even of such enormous size must be very slight, if appreciable. The magnetic needle, however, undergoes violent disturbance upon their appearance.

In an article in Knowledge for April and May, 1892, Mr. Maunder brings forward some important evidence in regard to the connection between sun spots and magnetic storms. The article concludes as follows:

In a period of nearly nineteen years, therefore, we have three magnetic storms which stand out preëminently above all others during that interval. In that same period we have three great sun spot displays—counting the two groups of April, 1882, together—which stand out with equal distinctness far above all other similar displays. And we find that the three magnetic storms were simultaneous with the greatest development of the spots. Is there any escape from the conclusion that the two have a real and binding connection? It may be direct, it may be indirect and secondary only, but it must be real and effective.

Consider that the period in question is practically some six thousand eight hundred days. A magnetic storm does not last many hours; a sun spot soon declines from its greatest development, or soon passes away from the center of the apparent disk. Suppose we take an outside limit, and give a period of two days to a giant spot to exercise its influence or a magnetic storm to expend its violence; what are the probabilities against 3 out of 3,400 of such periods of the one phenomenon agreeing with 3 out of 3,400 of the other, if they are not related? If 3,400 numbers were placed in one box and 3,400 more in a second, and one from each box were drawn at a time, what is the chance that the three highest numbers would be drawn from the one box simultaneously with the three highest from the other, each to each, if the matter had not been prearranged? Indeed, we might legitimately call the coincidence of April, 1882, a double one, and ask the odds against the four highest numbers from each box being so drawn.

Between sun spots and storms of the second magnitude it is more difficult to make a satisfactory comparison, because it is not so easy to frame a satisfactory definition as to what constitutes a secondary disturbance. Nevertheless, the following brief table of large sun spots seen since the beginning of 1881, which were coincident with considerable disturbances, may prove of interest. The spotted area is given in millions of square miles;

Date.	Spotted area. Entire sun.	Spotted area. Largest group.	Date.	Spotted area. Entire sun.	Spotted area. Largest group.
1881—January 31	1,295	686	1883—November 1	2,100	784
September 12	2,089	917	November 19	3,682	1,600
1882—October 2	2,480	1,234	1884—March 2	1,510	609
October 5	2,065	1,198	April 24	2,348	1,510
1883—April 3	1,545	607	April 30	1,746	897
April 19	2,170	670	1885—January 23	1,687	592
June 30	3,650	2,210	February 5	1,345	571
July 11	1,887	1,009	February 13	1,569	480
July 29	1,425	1,264	May 26*	1,923	647
September 17*	2,017	1,263	June 24*	2,348	1,681
October 16	4,730	1,733	July 18	1,835	504
October 20	1,650	1,369	1891—November 22*	1,966	1,371

Some of the above, those marked with an asterisk, may fairly be taken as confirming, though with less definiteness, the conclusion drawn from the correspondences between the greatest spots and the greatest storms. But with the others it is not so. Spots as important have been seen upon the sun, and the magnets have scarcely fluttered, and storms as distinct have occurred when there have been only few spots, and those but small, upon the visible disk of the sun. The table is important, therefore, not as adding to the weight of the evidence in favor of the connection between sun spots and magnetic disturbances, but as emphasizing a point which must not be forgotten. Though the diurnal and annual changes of terrestrial magnetism conclusively prove the solar influence upon it, though the conclusion between the general sun-spot cycle and the general magnetic cyle is clearly established, though even in minor irregularities the two curves closely correspond, and though unusually large sun spots are answered by unusually violent magnetic storms, we can not, as yet, proceed further and express the magnitude or character of the magnetic disturbances in terms of the spotted area of the sun or of its principal groups at the time of observation. The conclusion to my own mind seems to be that though sun spots are the particular solar phenomenon most easily observed, we must not infer, therefore, that their number and extent afford the truest indication of the changes in the solar activity which produce the perturbations we remark in our magnetic needles.

Solar prominences.—Especial attention has been given to the photography of solar prominences by Prof. G. E. Hale of the Kenwood observatory, Chicago, and by M. Deslandres of the Paris observatory. Prof. Hale suggested two plans for the purpose; the first was to allow the image of the sun to drift across the radial slit of a powerful spectroscope, the driving clock of the telescope being slowed to produce the drift. If then there were a prominence on the sun's limb the length of any bright line at the focus of the spectroscope would define the height of the prominence, and as the sun drifted across the slit this line would continually change in length. If now the line in use were made to pass through a slit just within the focus of the observing telescope of the spectroscope called the "second slit," so as to be in focus on a plate beyond the slit, all that is required to photograph the prominence is to move the plate slowly at right angle to the second slit. Fresh portions of the plate are thus exposed to corresponding portions of the promi-

nence, and the prominence image is built up from a succession of bright line images of the slit. In the second method proposed, the clock of the equatorial is so adjusted that the image of the sun is kept in a fixed position. The plate on the end of the collimator which carries the slit, is then slowly moved across the sun's limb at the point where the prominence is present, and a second slit moving at the same speed before a stationary plate excludes the light from the spectrum on either side of the line in use, and reduces fogging to a minimum.

In April, 1891, Mr. Hale secured the first photograph of the spectrum of a prominence obtained without an eclipse. This showed two very strong, bright lines nearly at the centers of the dark solar bands H and K. The same lines were photographed on subseqent occasions, but it was not until June 23, that any new lines were discovered. On this occasion four lines were obtained in the ultra-violet—a number since increased to six. Of these six, 5 lines belong, unmistakably, to the series of hydrogen lines discovered by Dr. Huggins, in the ultra-violet of the spectra of Sirian stars. The sixth line forms a close double with one of these hydrogen lines (α) but its origin has not yet been accounted for.

Mr. Hale's conclusion that H and K are not due to hydrogen, is abundantly confirmed by Prof. Young and also by M. Deslandres, since the measures have shown beyond a doubt that the "companion line to H," and not H itself, is the one really due to hydrogen. Mr. Hale and M. Deslandres ascribe these two giant bands of the solar spectrum to calcium.

Mr. Hale has also met with considerable success in photographing the forms of solar prominences, some of the photographs showing a satisfactory amount of detail. In one instance a prominence photographed at Kenwood was being sketched by Herr Fényi at Kalocsa at the same moment of time, and drawing and photograph are in close accord. A suggestion by M. Deslandres that it might be possible to photograph the entire chromosphere at a single exposure has been carried into effect by Mr. Hale, by means of a "spectroheliograph," in which the slit of the spectroscope is made to travel across the image of the sun, and a precisely similar motion, but in an opposite direction, is given to a second slit nearly in the focus of the view telescope, and so arranged that the K line of the spectrum of the fourth order falls upon it. Since the K line is always bright in the spectrum of the chromosphere and prominences, it is easy, by shutting off the image of the sun by means of a diaphragm, to build up a complete picture of the entire chromosphere and prominences, and so to produce what may be described as an "artificial total solar eclipse." The discovery which Mr. Hale has made that the H and K lines are always reversed in the faculæ has enabled him to extend the application of this principle. If the diaphragm covering the image of the sun be discarded a photograph will be obtained, not merely of the chromosphere and prominences, but of the disc of the sun itself, showing the spots and

the faculæ, the latter being depicted, not merely when near the limb of the sun, but wherever they occur, even in the very center of the disc. In this manner it has been discovered that faculæ, invisible to the eye frequently float above the spots, and one series of photographs in particular, show how, on July 15, a luminous outburst formed, spread, completely hid a large group of spots, and passed away, all in a few minutes of time.

The *double* reversal of the H and K lines from faculae, a phenomenon shown upon photographs taken at Kenwood, Paris, and Stonyhurst, is a discovery of special interest as bearing upon the interpretation of the enigmatical spectrum of *Nova Aurigæ*, and Prof. Hale has supplemented this discovery by obtaining a similar result with an integrating spectroscope, the sun being treated as a star would be, its light as a whole, and not only from special regions of the disc, being subjected to examination.

M. Deslandres has been making further experiments upon photographing the corona without an eclipse. The principle upon which he proceeds is to obtain photographs of the sun from light of limited refrangibility, not by using colored media or stained plates, but by means of two prisms, the second of which is arranged so as to recompose the light dispersed by the first. But only certain rays from the first prism are allowed to fall on the second: the resulting image of the sun is, therefore, confined to those rays which can be selected at pleasure. M. Deslandres' purpose is, therefore, to find out for what rays the corona has the greatest brightness as compared with that of the sun, and to photograph the sun and its surroundings by their aid alone. (*See* Month. Not., 52:292; 53:277.)

ECLIPSES.

Eclipse of the moon, 1888, January 28.—In number 23 of the Publications of the Astronomical Society of the Pacific is an unusually satisfactory drawing by Prof. Weinek, showing the delicate shades of color exhibited by the eclipsed moon.

Eclipse of the sun, 1889, January 1.—Prof. Pritchett's report of the Washington University party, which was stationed at Norman, Cal., is illustrated by an excellent artotype, a composite reproduced by hand from four negatives. The evidence given by these photographs upon the structure of the corona is thus summarized "The marked structural features of the corona are (*a*) the so-called filaments, and (*b*) the streamers extending approximately in the direction of the ecliptic. The filaments extend over a region of 20 degrees or more on each side of the poles. They are straight lines of light arranged somewhat like the spines of a fan, and are not radial. The dark spaces between them are not entirely free of coronal matter, but can be traced in some cases to within a short distance of the sun's limb. The broad and strongly marked equatorial belt stretches directly across this mass of filaments,

apparently cutting off the filaments at the somewhat irregular line of separation. The impression conveyed to the eye is that the equatorial stream of denser coronal matter extends across and through the filaments, simply obscuring them by its greater brightness. There is nothing in the photographs to prove that the filaments do not exist all round the sun.

Eclipses of 1891 and 1892.—In the year 1891 there were two eclipses of the sun, an annular eclipse on June 6, and a partial eclipse on November 30–December 1; and two eclipses of the moon, May 23 and November 15, both total.

In 1892 there were also four eclipses, two of the sun and two of the moon: a total eclipse of the sun April 26, and a partial eclipse of the sun October 20; a partial eclipse of the moon May 11 and a total eclipse November 4.

Eclipse of the moon, 1891, May 23.—A total eclipse, visible throughout the western part of the Pacific Ocean, Australia, Asia, Africa, and Europe. No observations of special importance.

Eclipse of the sun, 1891, June 6.—Visible as an annular eclipse only in the northern part of Siberia and the Arctic Ocean. A few observations of contacts were secured in the western part of the United States.

Eclipse of the moon, 1891, November 15.—The total eclipse of the moon on November 15, 1891, was visible generally throughout North and South America, Europe, Asia, and Africa. The whole of the eclipse was visible in the eastern and central parts of the United States while in the western part the moon rose eclipsed. Dr. Döllen selected from photographic plates made at Potsdam some 138 stars to be occulted at established observatories, but the weather seems to have been generally unfavorable. A few contact observations were secured.

Eclipse of the sun, 1891, November 30.—A partial eclipse, visible only in the Antarctic ocean.

Eclipse of the sun, 1892, April 26.—Total eclipse, visible only in the Southern Pacific; no observations of importance reported.

Eclipse of the moon, 1892, May 11.—The phenomenon of the partial eclipse of the moon on May 11, 1892, was studied at Greenwich and elsewhere, and the occultation of a considerable number of small stars was observed.

Eclipse of the sun, 1892, October 20.—Partial eclipse, visible in North America; a few observations of contacts reported.

Eclipse of the moon, 1892, November 4.—Total eclipse visible generally in Europe and America. No observations of special importance.

SOLAR PARALLAX AND THE TRANSITS OF VENUS.

The United States transit of Venus observations.—In a report dated September 21, 1891, the Superintendent of the United States Naval Observatory states that no provision has yet been made for publishing

in detail the work of the American parties upon the transit of Venus in 1882—a fact greatly to be regretted. The publication of the work upon the 1874 transit is only partly completed and considerable work still remains to be done upon the reductions for 1882, though results for the solar parallax and certain elements of the orbit of Venus, which are practically final, have been published. Some occultations of stars by the moon, telegrapic determinations of differences of longitude, tidal observations, and pendulum experiments still remain to be reduced, for which, however, no funds seem to be available.

Dr. Auwers' result* for the German heliometer measures of the transit of Venus in 1874 is a solar parallax of $8''.877 \pm 0''.043$, there being in all 308 measures at four different stations; in 1882 four stations were occupied and 446 measures were obtained, the resulting parallax being $8''.879 \pm 0''.037$.

Dr. Battermann, of the Berlin Observatory, has deduced a value of the solar parallax from 250 occultations of stars between April, 1884, and October, 1885, having by careful observation been able to utilize the occultations of a considerable number of faint stars near new moon. The resulting solar parallax is $8''.794 \pm 0''.016$.

The determination of the solar parallax by means of meridian observations of Mars at opposition was attempted in 1862, and again in in 1877, but the results obtained were generally considered by astronomers as too large, there being indications of a systematic error in the observations of Mars, or of the comparison stars, or of both. A slight modification of the previous methods of observation was suggested by Prof. Eastman, and a circular was issued by the U. S. Naval Observatory requesting the coöperation of other observatories in the observation of Mars during the opposition in the summer of 1892.

PLANETS.

MERCURY: *Diameter of Mercury.*—A new determination of the diameter of Mercury has been made by Mr. Ambronn from heliometer observations at Göttingen, the mean result being $6''.580$, comparing favorably with the generally adopted value.

Transit of Mercury, May 9, 1891.—A transit of Mercury over the sun's disk took place on May 9, 1891, the first since November 7, 1881. The observation of these transits no longer possesses special importance, as the determination of the solar parallax, for which they are theoretically valuable, can now be made more accurately by other means. Observations of the contacts between the disks of the sun and planet are useful in determinations of the planet's orbit and the physical phenomena are sometimes of interest. The transit on May 9, 1891, was only

* Astron. Nachr. 3066.

partially visible in the United States. On the Pacific coast the sun was two or three hours high at the time of the first and second contacts; it had set in most places on the Atlantic coast before the first contact, and in Washington was only ten minutes high. Reports from twenty five observers in the United States have been forwarded to the Naval Observatory for reduction. The whole transit was visible in China, Japan, eastern Siberia, and the Malaysian Islands, while in England egress took place soon after sunrise. No phenomena of special importance seem to have been noted. In Europe several observers saw the "black drop" or ligament. At the Lick Observatory a careful series of observations was made, both visual and photographic, and the planet was looked for, but without success, before it entered upon the sun's disk.

For more than an hour after ingress the planet was also carefully examined, with the 36-inch Lick telescope, by Profs. Holden and Keeler. It "was perfectly round, and in the best moments sharply terminated . . . . Not the slightest trace of a satellite was seen; and both observers were confident that no such body could then be on the sun's face and escape detection unless it were exceedingly minute."

VENUS.—The conclusion reached by Schiaparelli that Venus rotates very slowly upon its axis, in fact in about the same time that it rotates about the sun, has been challenged by several observers. MM. Niesten and Stuyvaert, of the Brussels Observatory, have given the matter careful study, and M. Trouvelot has published a series of observations and sketches from 1876 to 1891, from which he concludes that the rotation does not differ greatly from twenty-four hours.

An exhaustive discussion of recent publications concerning the physical appearance of Venus is printed by Dr. Wislicenus in the *Vierteljahrsschrift*, v. 27, pp. 271–302. It is quite evident that further accurate observations are necessary.

The value of the diameter of Venus, deduced by Dr. Auwers from the heliometer measures by the German Transit of Venus parties, in 1874 and 1882, is 16″.80.

THE EARTH: *Variation of terrestrial latitude.*—One of the most important subjects that has been under discussion during the past two years—important to astronomy and geodesy alike—is the variation of terrestrial latitudes, the strong suspicion of which has been confirmed by recent very accurate observations, and when once admitted is abundantly fortified by the discussion of older observations.

There seems to be now distinct evidence of a rotation of the geographical round the astronomical pole in 427 days. The problem has of course attracted the attention of the ablest astronomers and mathematicians, but the credit for the ablest discussion and the most satisfactory solution is undoubtedly due to Mr. S. C. Chandler. The following summary of his work is taken from a review in the *Monthly Notices* (v. 53, No. 4).

Mr. Chandler's observations with the almucantar, in 1884 and 1885, first suggested to him, not only the possibility of a variation in latitude, but the law of the variation. Twelve months' observations were of course not sufficient to establish a periodicity of fourteen months, though they might suggest it; confirmation was, however, furnished by Dr. Küstner, who, in his determination of the aberration from a series of observations coincident in time with those of the almucantar, came upon similar anomalies. Further evidence bearing on the question was forthcoming in the parallel determinations at Berlin, Prague, Potsdam, and Pulkowa, which showed changes in apparent latitude, not only strikingly sympathetic among themselves, but of the same range and periodicity as those noticed in 1885; and Mr. Chandler "was led to make further investigations on the subject, which seem to establish the nature of the law of these changes, and proceeded (1891, November) to present them in due order."

The consequent series of papers in the *Astronomical Journal* can hardly fail to take its place as one of the astronomical classics. The following summary is made purposely very brief because the series is not yet complete, and no doubt much still remains to be said on such an important subject. But it will be seen that during the year 1892 (including perhaps the end of 1891) a most important advance has been made in fundamental astronomy.

The first paper (regarding that already mentioned as preliminary) deals with the observations with the Pulkowa vertical circle (1865–1875), "which have been provocative of so much inquiry, so far without any solution of the anomalies which they show in regard to the question of latitude variation," and the Washington prime vertical observations (1862–1867), "the most accurate determinations of declination ever made at the Naval Observatory," which yet "resulted in anomalous values of the aberration constant in the different years and a negative parallax in all." Mr. Chandler finds that a 427 day period in the latitude "furnishes the true key to the troublesome discordances in the Pulkowa latitudes," and "traces to their origin the anomalies in the Washington observations." Further, the comparison of the two series leads to the same conclusion as that already shown from the simultaneous series at Berlin and Cambridge (United States) in 1885 as to the direction of the polar motion. In the next paper it is mentioned that observations at Melbourne (1863–1884) and Leyden (1863–1867) are in complete accordance with those made at the same time at Pulkowa and Washington; and that the 427 day period accounts for the contradictory results obtained by Dr. Van Hennekeler at Leyden. The motion of the earth's pole for the period 1860–1870 is thus fairly established. The author proceeds to consider earlier observations. In the papers numbered 3 and 4, the systematic errors of Bradley's observations, which were reduced afresh for this purpose, are discussed, particularly the collimation error. It is then concluded that the observations

indicate a rotation of the pole in little more than a year and with a larger radius than that of 1860–1880, the range being about 1″. In the same paper Mr. Chandler states that Brinkley's observations at Dublin (1808–1813 and 1818–1822) are found to indicate a rotation in about a year, with range more than 1″, "wherein lies the solution of the hitherto unsolved enigma of Brinkley's singular results which led to the spirited and almost acrimonious dispute between Brinkley and Pond with regard to stellar parallaxes." The details were promised in a later paper, but have not yet been given, owing doubtless to the necessity of attending to a vitally important point which will presently appear.

In papers 5 and 6 are presented the results of an enormous mass of reductions extending from 1837 to 1891, made at no fewer than seventeen observatories. The whole is broken up into forty-five series, or short groups, for the purposes of this particular discussion; and the result of this minute inquiry, confirmed (or perhaps suggested) by the observations of Bradley and Brinkley above mentioned, seemed clear, viz, that the "instantaneous rate of angular motion of the pole has been diminishing during the last half century at a sensibly uniform rate, by its one-hundred-thousandth part."

Mr. Chandler was led to modify this statement in a remarkable manner and within a few weeks.

Astronomers had hesitated to accept the 427-day period, even in face of the very strong evidence of the 1860–1880 observations, owing to the difficulty in accounting for it theoretically. It had been pointed out by Euler that, treating the earth as a rigid body, the period of rotation of the pole must be 306 days. Prof. Newcomb, however, happily pointed out that a qualified rigidity (either actual viscosity or the composite character due to the ocean) afforded an explanation of this longer period; and after this suggestion Mr. Chandler's 427-day period was well and even warmly received. But the further elaboration of this hypothesis by a changing period was a new difficulty.

Prof. Newcomb, who had reconciled the first article of the hypothesis with theory, was not slow to declare that the second was irreconcilable. Mr. Chandler's reply, in paper 6, is a model of controversial courtesy and skill. He says: "It should first be said that in beginning these investigations I deliberately put aside all teachings of theory, because it seemed to me high time that the facts should be examined by a purely inductive process; that the nugatory results of all attempts to detect the existence of the Eulerian period probably arose from a defect of the theory itself; and that the entangled condition of the whole subject required that it should be examined afresh by processes unfettered by any preconceived notions whatever. . . . The appeal to observation, treated irrespective of theory in the present series of papers, shows that a rotation of the pole really exists, but (*a*) at a daily rate of but 0″.85 (for 1875), and (*b*) that this velocity is

subject to a slow retardation, which in its turn is not uniform . . . The result (a) was at first pronounced impossible, and it is even now so regarded in some quarters. Prof. Newcomb, however, soon after found the defect in the theory, and is now as cordially in favor of the result given by observation as he was originally against it.. . . Now, may it not reasonably be asked, if the direct deduction from observation has led to the correction of the theory in the first particular, is it beyond hope that it may do so in regard to the second?"

Such a truly scientific attitude inspires confidence that the search is being rightly conducted: but the most sanguine could hardly be prepared for the reconciliation of observation and theory in the very next paper of the series, published six weeks later.

By this time Mr. Chandler had rearranged his material, and found, not *one variable* rotation of the pole, but *two constant* rotations (with a qualification), one in 427 days and the other in about a year. The qualification is that the *amplitude* of the latter is apparently variable, not the period. The superposition of these two rotations is almost exactly equivalent, for the observations available, to the law (or summary of observation, as it might fairly be called) previously announced. To make clear the novelty of this discovery it may be remarked that, although fluctuations in zenith distances of annual period have long been recognized, they have generally been ascribed to temperature effects, in which case the maxima and minima for all stations in the Northern Hemisphere should occur at the same epoch—say, midsummer and midwinter. But this is not the case with the annual term now revealed. The epoch changes with the longitude, showing that the pole moves just as in the case of the 427-day term.

It is somewhat remarkable that two formulæ differing so much in form should be found to represent the observations almost equally well. Apparently this is to be attributed chiefly to the variability in amplitude of the annual term, and as yet this variability has not been accounted for. But to have advanced the work to this stage in such a short time is a great achievement, and much may confidently be expected from Mr. Chandler's future work. He points out, in a paper dated January 2, 1893, that the discovery of these periodic inequalities in the latitude makes it necessary to go over much old work afresh, and is himself leading the way with a discussion of the aberration constant.

In the same paper he shows that the recent results obtained at Berlin, Prague, Strasburg, Pulkowa, Rockville, and Honolulu give a mean correction to his final formula of only five days in the epoch; "and the accordance of the separate values is high testimony to the skill of the observers, to whom astronomers owe a deep debt of gratitude for their laborious and conscientious work."

Standard time.—In reviewing the recent progress made in the introduction of uniform standards of time M. Pasquier states that in Can-

ada Parliament has declared as legal the normal hours from Greenwich adopted since 1883 by railways and later by a great number of towns. In England a commission has reported favorably upon the system of hourly meridians, and the Government has strongly recommended it to the colonies. In France, Paris mean time is used for all the country, including Algeria. In Belgium a commission has recommended the hourly meridian system, with Greenwich as the starting point. In Holland the Government has authorized the adoption of Greenwich time for interior railway service. In Prussia mean European time (mitteleuropäische Zeit or M. E. Z.) which is one hour greater than Greenwich time, replaced Berlin time from the 1st of June, 1891, for the railway service of the interior. Bavaria, Würtemberg, and Baden have also decided on M. E. Z., which will also be used in Alsace Lorraine. Austria and Hungary adopted M. E. Z. from October 1, 1891, for railway, post, and telegraph service, and there is a strong feeling for its adoption in civil life. In Italy, at the instance of the Academy of Sciences of Bologna, which favors the meridian of Jerusalem, there was a plan for assembling a new congress at Rome, but this, however, seems to have been abandoned. There is here as well as in Switzerland a strong sentiment in favor of Greenwich as the standard.

At the Cape of Good Hope the extension of railways brought about the adoption of a single standard time throughout the colony in February, 1892. The meridian one and one-half hours east of Greenwich is in use for all purposes in Cape Colony and the Orange Free State, and all time signals are given at Greenwich noon.

Sky glows.—The after glows that attracted so much attention in 1883 and 1884 showed some signs of return, though in lesser degree, in the early part of 1891. The tint and general appearance are reported to have greatly resembled the auroral displays.

The systematic study of these "luminous night clouds" has been taken up by Prof. Foerster and Herr Jesse, of the Berlin observatory.

The Moon.—A valuable contribution has been made to the study of the moon in "An essay on the distribution of the moon's heat and its variation with the phase," by Mr. F. W. Very, of the Allegheny Observatory—a paper which gained the prize proposed in July, 1890, by the Utrecht Society of Arts and Sciences. Mr. Very's investigation was made with one of Langley's "bolometers," and the principal results may best be described in the author's own words:

First, that visible rays form a much larger proportion of the total radiation at the full than at the partial phases, the maximum for light being much more pronounced than that for the heat. Next, as has been foreseen from the eccentricity of the heat areas, their greater extension toward the western limb, and the greater steepness of the sunset than of the sunrise gradient, the diminution of the heat from the full to the third quarter is slower than its increase from the first quarter to the full. Finally, there is a fair agreement between these results and those of Lord Rosse, which extends even to some minor details, such as the attainment of the highest heat at little before the full.

In a discussion of the moon's atmosphere Mr. Ranyard expresses the opinion that the moon can not have an atmosphere one two-thousandth part as dense as that of the earth at sea level. It must, however, be remembered that, were our atmosphere transferred to the moon, its density would only be one-sixth what it is on the earth.

Professor Weinek, of Prague, who has been making a special study of the Lick photographs of the moon, has detected several new rills and craters on the negatives.

MARS.—Mars was in opposition to the sun on August 3, 1892, and though the planet was also at this time very favorably situated as regards its proximity to the earth, its great southern declination was a serious impediment to observation in the northern hemisphere. At the Harvard observatory station, Arequipa, Peru, the planet was, however, almost in the zenith, and full advantage was taken of this by Prof. W. H. Pickering and his assistants. Many of Schiaparelli's canals were identified; some were seen double, and marked changes were detected in progress in various parts of the planet, especially in the neighborhood of the *Lacus solis* or Terby sea. Prof. Pickering and other observers detected a number of bright white spots besides the polar snow cap.

In an article in the March number of *L'Astronomie*, 1891, Flammarion describes various changes in the topography of Mars, the most striking of which are also in connection with the Terby sea. Drawings are given of its appearance in 1877, 1879, 1881, and 1890; briefly, it seems to have undergone cleavage, and while some former "affluent canals" have disappeared, other new ones have developed. The strait called Herschel II has been transformed into a straight double canal.

JUPITER: *Discovery of a fifth satellite.*—The most interesting astronomical event of the year 1892 was the discovery by Barnard, with the 36 inch Lick equatorial, on September 9, of a fifth satellite of the planet Jupiter.

Following is Prof. Barnard's own account of his discovery, in describing his search for new objects in the Astronomical Journal:

Nothing of special importance was encountered until the night of September 9, when, in carefully examining the immediate region of the planet Jupiter, I detected an exceedingly small star close to the planet and near the third satellite. I at once measured the distance and position angle with reference to satellite III. I then tried to get measures referred to Jupiter, but found that one of the wires had got broken, and the other loosened. Before anything further could be done the object disappeared in the glare about Jupiter. Though I was positive the object was a new satellite, I had only the one set of measures, which was hardly proof enough for announcement.

I replaced the wires the next morning. The next night with the great telescope, being Prof. Schaeberle's, he very kindly gave the instrument up to me, and I had the pleasure of verifying the discovery, and secured a good set of measures at elongation.

Just what the magnitude of the satellite is it is at present quite impossible to tell. Taking into consideration its position, however, in the

glare of Jupiter, it would perhaps not be fainter than the thirteenth magnitude.

The satellite has been seen and its position observed at the University of Virginia, at Princeton, at Ealing, and at Evanston; the 18½ inch refractor at Evanston being apparently the smallest instrument with which it has thus far been seen, and it was then reported as being a much more difficult object than Ariel or Umbriel, the satellites of Uranus, though Mr. Reed with the 23-inch Princeton glass found it an easier object than Ariel.

The new satellite's orbit seems to lie sensibly in the plane of Jupiter's equator; the distance of the satellite from the center of the planet is probably over 110,000 miles and its period of rotation about $11^h\ 57^m\ 37^s$.

Diameter of Jupiter.—An admirable series of measures of the diameter of Jupiter, by Dr. Schur, with the Göttingen heliometer, is published in No. 3073 of the *Astronomische Nachrichten.* The effect of personal equation was eliminated by the use of a reversion prism eyepiece. Dr. Schur finds the disk a sensibly true ellipse with diameters $37''.4$ and $35''.0$, a flattening of 1–15½.

Mr. Burnham communicated to the November meeting of the Royal Astronomical Society, in 1891, a paper on the spots and markings of Jupiter as observed with the 12-inch equatorial of the Lick Observatory. Noting the decided changes of color in the different markings on the planet's surface, he expresses the opinion that the red color is an indication of age, or, in other words, when a spot or marking other than the white spots first appears it is dark or black, but after some time turns red. During the year 1891 the planet was extremely interesting, owing to the remarkable amount and variety of detail displayed on its surface. The two hemispheres were, as usual, strongly in contrast in their individual markings. In the southern hemisphere, besides the great red spot, new spots appeared, and a great number of round white spots were visible. These white spots are quite characteristic of the southern hemisphere, though individual white spots have at rare intervals been seen in the northern hemisphere. In the latter a system of small dark spots appeared, with very short periods of rotation. Mr. Burnham reports that the great red spot had regained much of its former distinctness, both in color and form.

SATURN.—On September 22, 1891, the earth passed through the plane of Saturn's rings. From the 22d of the month to October 30 the earth was above the plane of the rings, while the sun was below that plane and, consequently, shining on the southern side of the rings. After October 30 the sun was again shining on the north side. The phenomenon of the disappearance of the rings was described by several observers.

URANUS.—A search for new satellites made by several observers at the Lick Observatory from 1889 to 1891 has resulted negatively. The

observers were satisfied "that no new satellite half as bright as Ariel at elongation exists within the orbit of Umbriel. It is not likely that any such object exists within the orbit of Titania."

NEPTUNE.—Mr. Asaph Hall, jr., finds that observations of the satellite with the 26-inch Washington refractor from October, 1891, to March, 1892, confirm the reality of the slow motion, nearly proportional to the time, of the orbit plane of the satellite with respect to the orbit of Neptune, to which Mr. Marth called attention and which M. Tisserand shows may result from a slight flattening of the planet.

MINOR PLANETS.

Asteroids of 1891.—Of the asteroids announced in the last report, No. 286 has been named Iclea, 296 Phaëtusa, 297 Caecilia, 298 Baptistina, 299 Thora, 300 Geraldina, 301 Bavaria. An asteroid, discovered on November 14, 1890, by Charlois, at Nice, and subsequently found to be a new one, has been named Clarissa. To No. 323, photographed by Dr. Wolf November 28 (the first asteroid discovered by photography), he has given the name Brucia, in honor of Miss Catherine W. Bruce, who has contributed so generously for the advancement of astronomy.

In 1891 twenty-two new asteroids were added to the group revolving between Mars and Jupiter, and photography now having become a powerful aid in the detection of these small bodies, the number still likely to be found seems almost limitless. The last on the list for 1891, No. 323, was discovered by Dr. Wolf upon his photographic plates. Another asteroid was, in fact, found upon the same plate, but it proved to be identical with 275 (Sapientia).

Palisa, on August 14, 1891, discovered what was for a time supposed to be a new planet, but it was found to be identical with 149, Medusa, discovered in 1875; 275, which had not been seen since the opposition of its discovery (1888), has been found again by the aid of photography; 318 is interesting from the almost exact commensurability of its period with that of Jupiter.

No. 302, Clarissa (discovered November 14, 1890), was not included in the last list published, and is, therefore, introduced here to make the lists complete.

List of minor planets of 1891.

Number.	Name.	Discoverer.	Date of discovery.
			1890.
302	Clarissa	Charlois at Nice	Nov. 14.
			1891.
303	Josephina	Millosevich, at Rome	Feb. 12
304	Olga	Palisa, at Vienna	Feb. 14
305	Gordonia	Charlois, at Nice	Feb. 16
306	Unitas	Millosevich, at Rome	Mar. 1
307	Nike	Charlois, at Nice	Mar. 5
308	Polyxo	Borelly, at Marseilles	Mar. 31
309	Fraternitas	Palisa, at Vienna	Apr. 6

List of minor planets of 1891—Continued.

Number.	Name.	Discoverer.	Date of discovery.
			1890.
310	Margarita	Charlois, at Nice	May 16
311	Claudia	do	June 11
312	Pierretta	do	Aug. 28
313	Chaldaea	Palisa, at Vienna	Aug. 30
314		Charlois, at Nice	Sept. 1
315	Constantia	Palisa, at Vienna	Sept. 4
316		Charlois, at Nice	Sept. 8
317	Roxane	do	Sept. 11
318		do	Sept. 24
319		do	Oct. 8
320	Katharina	Palisa, at Vienna	Oct. 11
321		do	Oct 15
322	Phaeo	Borelly, at Marseilles	Nov. 27
323	Brucia	Wolf, at Heidelberg	Nov. 28

Asteroids of 1892.—The further and very successful application of photography to the discovery of asteroids by Dr. Wolf, at Heidelberg, and by M. Charlois, at Nice, resulted in such rapid additions to the list that the notation of these bodies was thrown into the utmost confusion. Hitherto the simple numbering in the order of discovery had been a rule easily applied by the discoverer, but where several asteroids were found upon a single photographic plate it was not always possible to determine until later observations and computations whether they were really new asteroids or not, and when the planetary character of the object was recognized it was frequently found imprinted upon some earlier photograph.

It was accordingly suggested, in No. 266 of the *Astronomical Journal*, that as a temporary omission of the number is attended with less inconvenience than is caused by the employment of an erroneous one, the numbers for the asteroids after number 322 should be omitted until the difficult task of fixing a definite enumeration should be delegated by common consent to some one authority to which all could defer.

Common consent seemed to point to the Berlin Rechen Institut as the only place actually in possession of the needful resources for solving the questions of identity continually arising, and it was agreed that to avoid further confusion Prof. Krueger, director of the Kiel observatory, the European "Central-Stelle," and editor of the *Astronomische Nachrichten*, should assign to each asteroid a provisional notation (1892 A, 1892 B, 1892 C, etc.) in the order of its announcement to the "Telegraphische Central Stelle;" and that the definitive numeration should be subsequently undertaken by Prof. Tietjen, director of the Rechen-Institut, in Berlin. In this definitive assignment of numbers those asteroids will be omitted, for which sufficient material is not available for a determination of the orbits.

The first asteroid to which the new notation was assigned was that discovered by Wolf, at Heidelberg, on August 22, 1892; it was provisionally known as 1892 A, and subsequently received its more permanent designation, number 333, from Prof. Tietjen, and its name, Badenia, from the discover.

In 1892 thirty new asteroids were announced; one of these, 1892 B, has already proved to be identical with Erigone, 163; and it is possible that further study will identify some of the others.

Some slight discrepancies are still found in the different lists of asteroids for the year, but as the new system of notation becomes established they will probably disappear.

In the following list all the discoveries were by photography except 324, 326, 327, and 331. In the case of the photographic discoveries the date given is that of the earliest photograph on which the planet appears. It was in many cases not noticed on the plate till considerably later, which accounts for the departures from chronological order in the "date of discovery":

List of minor planets of 1892.

Letter.	Number.	Name.	Discoverer.	Date of discovery.
....	324	....	Palisa, at Vienna	Feb. 25
....	325	Heidelberga	Wolf, at Heidelberg	Mar. 4
....	326	Tamara	Palisa, at Vienna	Mar. 19
....	327	Columbia	Charlois, at Nice	Mar. 22
....	328	Gudrun	Wolf, at Heidelberg	Mar. 18
....	329	Svea	......do	Mar. 21
....	330	Ilmatar	......do	Mar. 19
....	331	....	Charlois, at Nice	Apr. 1
....	332	Siri	Wolf, at Heidelberg	Mar. 19
1892 A	333	Badenia	......do	Aug. 22
1892 B	163	Erigone	......do	Sept. 1
1892 C	335	Roberta	Staus, at Heidelberg	Sept. 1
1892 D	336	....	Charlois, at Nice	Sept. 19
1892 E	337	....	......do	Sept. 22
1892 F	338	....	......do	Sept. 25
1892 G	339	Dorothea	Wolf, at Heidelberg	Sept. 25
1892 H	340	....	......do	Sept. 25
1892 J	341	....	......do	Sept. 25
1892 K	342	....	......do	Oct. 17
1892 L	334	....	......do	Aug. 23
1892 M	344	....	Charlois, at Nice	Nov. 15
1892 N	343	....	Wolf, at Heidelberg	Nov. 15
1892 O	....	....	Charlois, at Nice	Nov. 23
1892 P	....	....	......do	Nov. 25
1892 Q	....	....	......do	Nov. 28
1892 R	....	....	......do	Nov. 28
1892 S	....	....	......do	Dec. 8
1892 T	....	....	......do	Dec. 9
1892 U	....	....	......do	Dec. 14
1892 V	....	....	Wolf, at Heidelberg	Dec. 16

OBSERVATORIES.

The chief sources of information concerning the recent work of astronomical observatories are the *Vierteljahrsschrift der Astronomischen Gesellschaft*, for continental and a few American observatories, and the *Monthly Notices* for English observatories; in addition to these are the reports of the observatories themselves—though few publish independent annual reports—and notes in current journals, chiefly the *Observatory* and the *Sidereal Messenger*.

In the following résumé the length of the notes is by no means always in proportion to the importance of the institution. The character of the work of the older observatories is generally too well known to require more than the briefest mention, while for the new observatories an effort is made to put on record as much information with regard to the equipment, etc., as can be found. In most instances it has not seemed necessary to distinguish between the two years covered by the review.

Among papers of interest on observatories is a series of notes on visits to some American observatories made by Mr. H. F. Newall, of the Cambridge Observatory, England, and published in the *Observatory*.

ABASTUMAN.—A new mountain observatory has been established at Abastuman ($2^h\ 51^m\ 25^s$ E. $+ 41^\circ\ 42'.4$). It is 4,500 feet above sea level and is equipped with a 9-inch telescope by Repsold.

ADELAIDE: *Todd*.—Reobservation of Weisse stars; observations of Jupiter; weather service.

ALABAMA UNIVERSITY.—An astronomical observatory attached to the University of Alabama, near Tuscaloosa, was completed in the summer of 1844. The building was originally 54 feet in length by 22 in breadth in the center. In 1858 another apartment, 40 feet in length by 20 in width, was added to the east wing. The instruments consist of a 4-inch transit circle of 5-feet focus by Simms, the circle being 3 feet in diameter, divided to five minutes, and read by four microscopes to single seconds; a clock by Molyneaux; an equatorial, also by Simms, of 8 inches aperture and 12 feet focus, provided with a filar micrometer and double image micrometer, the hour circle being divided to one second of time and the declination circle to five seconds of arc, read by opposite verniers. As an accessory to the equatorial there is an excellent clock by Dent. There are also two portable achromatic telescopes—one by Dolland of 7 feet focal length and 4 inches aperture, the other by Simms of 5 feet focal length and 3 inches aperture—and reflecting circle by Troughton, of 10 inches aperture, read by three verniers to twenty seconds.

The observatory was built and the instruments purchased and mounted under the supervision of Prof. F. A. P. Barnard. A woodcut of the building is given in number 15 of the publications of the Astro-

nomical Society of the Pacific, taken from the report of the United States Commissioner of Education for 1889.

ALLEGHENY: *Keeler*.—At a meeting of the board of trustees of the Western University of Pennsylvania on May 11, 1891, J. E. Keeler, of the Lick Observatory, was elected professor of astrophysics in the university and director of the Allegheny Observatory, Mr. F. W. Very being associated with him as adjunct professor of astronomy.

Through the generosity of Mrs. William Thaw the observatory has been provided with a very powerful spectroscope by Brashear: a new driving clock was presented by Mr. William Thaw, jr.

ARMAGH: *Dreyer*.—Micrometric measures of nebulæ: physical observations of Jupiter.

ATHENS: *Eginitis*.—The National Astronomical and Meteorological Observatory at Athens has been reorganized under the directorship of Prof. Eginitis.

BAMBERG: *Hartwig*.—The large heliometer of 184 millimeters aperture has been brought into regular use. Observations of variable stars and of a few occultations have been made, besides observations for the determination of change of latitude.

BASEL: *Riggenbach*.—Instruction of students.

BERLIN: *Foerster*.—Transit circle observations, measures of double stars, etc.

BERMERSIDE (Halifax): *Crossley*.—Measurement of double stars: observation of the phenomena of Jupiter's and Saturn's satellites. Meteorological observations.

BIDSTON: *See* Liverpool.

BIRR CASTLE: *Earl of Rosse*.—Observations for lunar heat. Meteorology.

BONN: *Küstner*.—Prof. Deichmüller was succeeded as director on October 1, 1891, by Dr. Küstner. Observation of the zone $+40°$ to $+50°$ was completed.

BOSTON UNIVERSITY.—A small observatory has been erected for purposes of instruction. Lat. $+42° 21' 32''.5$; long. $4^h 44^m 15^s$ west of Greenwich. The chief instrument is an equatorial of 7 inches aperture and 8 feet 1 inch focus, objective by Clacey and mounting by Saegmuller.

BRESLAU: *Galle*.—Time service and meteorological observations. The one hundredth anniversary of the observatory was celebrated in 1891.

BRUSSELS: *Folie*.—Cloudy weather, an insufficient personnel, and the disturbance incident to the removal of the observatory to Uccle greatly interfered with the work of 1890. M. Niesten has continued his observations on the physical aspect of Mercury, Venus, Mars, and Jupiter, with the 38 centimeter (15 inches) equatorial. Since the death of M. Fievez the spectroscope has been in charge of M. Spée.

BUDAPEST: *Konkoly*.—The new observatory of the Royal Meteorological Reichsanstalt consists of a transit room 6½ meters (21 feet) by

4 meters (13 feet) and a room for the refractor with a dome $4\frac{1}{2}$ meters (15 feet) in diameter. The instrumental equipment is very meager, consisting chiefly of a $4\frac{1}{2}$-inch telescope, a transit, clock, chronometer, chronograph, electrical and other subsidiary apparatus. The director reports but little astronomical work accomplished.

CAMBRIDGE (England): *Ball.*—Prof. Adams has been succeeded as director by Sir Robert Ball. Considerable progress has been made upon the zone work. The 25-inch Newall refractor has been used for physical observations of planets and photography of stellar spectra. A spectroscope has been provided from "the Bruce fund."

CAPE OF GOOD HOPE: *Gill.*—Transit circle observations of the sun, Mercury, Venus, and of stars for a new ten-year catalogue, stars occulted by the moon, stars employed for latitude determinations, etc.; with the heliometer, measures for stellar parallax and measures of Jupiter's satellites have been made, and with the zenith telescope, after its renovation, observations for an investigation of the constant of aberration. The photographic work has consisted of miscellaneous photographs of stars and planets, in addition to regular astrophotographic charting.

The catalogue of the Southern Photographic *Durchmusterung* has been made ready for the press.

CARLETON: *See* Goodsell.

CHAMBERLIN: *Howe*—The building has been completed at a cost of \$25,000.

CHICAGO—*See* Kenwood, Yerkes.

COLUMBIA (Missouri): *Updegraff*—The observatory of the University of Missouri (lat. $+38° 56' 50''$; long. $1^h 1^m 6^s.4$ west of Washington) was first built in 1853, and then consisted of a small wooden structure in which were mounted a 4-inch Fitz equatorial, a $2\frac{1}{16}$ inch transit by Brunner, a sidereal clock, and other smaller instruments. It was used for the purpose of instructing students in astronomy, and few changes or additions were made till 1880, when a $7\frac{1}{2}$-inch equatorial by Merz & Mahler was bought. The building was then removed to another part of the college grounds and enlarged by the erection of a brick tower, with a dome, for the newly acquired telescope. Soon after a sidereal clock, a chronograph, and spectroscope, all by Fauth & Co., were purchased. A 2-inch altazimuth, by Blunt, of New York, had been bought some years before. The director at that time was Prof. Joseph Ficklin, who died in September, 1886.

Prof. Milton Updegraff was appointed director in July, 1890, and while much of his time is taken up in teaching classes in astronomy and mathematics, he has done excellent work in the observation of planets and comets, besides a redetermination of latitude and longitude, the latter by telegraphic connection with the observatory of Washington University, St. Louis. The observatory building has been enlarged by the addition of an office room and a library.

COPENHAGEN: *Nielsen.*—M. Victor Nielsen at his private observatory has a 7½ inch refractor by Reinfelder and Hertel, the objective of Jena glass. The work has been chiefly upon the moon.

CROWBOROUGH HILL: *Roberts.*—Mr. Isaac Roberts' new observatory is one of the highest points in the south of England, 780 feet above sea level. The hemispherical dome has two slits to effect thorough ventilation. Photographs of stars, planets, nebulæ, and clusters. A photographic search has been made for a trans Neptunian planet.

DAKOTA AGRICULTURAL COLLEGE (Brookings, Dakota.)—Founded in 1891: equipment, 5-inch equatorial, 2-inch transit, clock and chronograph.

DENVER.—*See* Chamberlin.

DRESDEN: *Dr. B. von Engelhardt.*—Observations of comets, nebulæ and asteroids, and micrometric measures of Bradley stars.

DUDLEY: *Boss.*—Miss Catherine Wolfe Bruce, of New York city, who is already known for her munificent gifts in aid of astronomy, has given $25,000 to the Dudley Observatory for the increase of its permanent endowment. From various sources the additional sum of $31,700 has been secured to defray the cost of rebuilding the observatory on a new site and of furnishing it with a new equatorial of 12 inches aperture, together with other improvements in its equipment. The cost of the telescope is provided for by Robert C. and Charles L. Pruyn; it is to be of the most approved modern construction. The cost of re-establishing the Olcott meridian circle (8 inches aperture), constructed by Pistor and Martins, of Berlin, in 1858, together with a collimating meridian mark and other improvements, is also provided for. The old site is very unfavorable to astronomical observation, owing to its proximity to the four tracks of the New York Central Railroad, which with a very heavy traffic, group around the base of Observatory Hill at a distance of about 150 yards from the instruments. The new site is about 2 miles southwest of the present location upon a plot of about 6 acres.

DUNSINK: *Rambaut.*—On February 20, 1892, Sir Robert Ball was appointed to succeed Prof. Adams at Cambridge, and the vacancy in the directorship of the Dunsink Observatory was filled October 22 by the appointment of Dr. A. A. Rambaut. Dr. Rambaut's assistant is Mr. A. E. Lyster. The 15 inch reflector has been used for stellar photography, principally for determinations of stellar parallax.

DÜSSELDORF: *Luther.*—Observations of asteroids and computation of ephemerides. The passage of railroad trains at a distance of 320 meters from the observatory has not seriously interfered with the observations.

EALING: *Common.*—An excellent 5-foot mirror and a new grating spectroscope have been made for the great telescope. Photographs of nebulæ and of the moon have been taken.

EDINBURGH: *Copeland.*—The reduction of the meridian observations

of nebulæ has been undertaken and some further observations have been made at Dunecht, but little observing has been done pending the completion of the new buildings. The main building of the new observatory is to be 180 feet from east to west, terminating in two towers surmounted by domes, or rather "drums." The eastern tower, rising to a height of 75 feet, will contain the 15-inch Grubb refractor, while the 24-inch reflector from the old site at Calton Hill will be mounted in the western dome. A single range of rooms, opening on a corridor on the south, extends from tower to tower. The roof is designed as an asphalted platform, affording free communication between the towers. Beginning at the west there are a spectroscope room, general laboratory, electrical room, cleaning room, mechanic's workshop, chronograph and class room. Light and dark photographic rooms, as well as a computing room for the equatorial and photographic work, are in the eastern tower. A central extension of the building toward the south, 80 feet by 26 feet, will contain the chief computing room, hallway, etc., director's room, and fire-proof library—34 feet by 23 feet, with a light iron gallery affording access to the upper shelves. An upper story to the southern part of this portion of the building, 66 feet in length, is designed for optical work. In the basement will be placed the heating apparatus, a dynamo, and accumulators for supplying electricity for lighting the observatory and illuminating the instruments. In the observatory there will thus be but one chimney.

The transit circle will be in a separate building, with light walls and roof of corrugated iron, 80 feet west of the western tower, accessible by a covered way. The remaining buildings are the astronomer's house, two assistants' houses, and a gate lodge.

GENEVA: *Gautier*.—Col. Emile Gautier died on February 24, 1891, and was succeeded in the directorship by his son, R. Gautier. The principal work of the observatory is the testing of watches and chronometers, and meteorological observations. A number of observations of comets have also been made.

GLASGOW.—Meridian circle observations.

GÖTTINGEN: *Schur*.—Observations of asteroids, comets, and Præsepe, and measures for stellar parallax; regular meridian observations, and physical observations of the moon, Jupiter, Saturn and Uranus.

GOODSELL: *Payne*.—The observatory of Carleton College received a new name, in honor of Mr. C. F. Goodsell, the founder of Carleton College, on June 11, 1891.

The new Williams equatorial, costing $15,000, was installed in 1891. Its clear aperture is 16.2 inches and focal length 22 feet, the lenses having been figured by Brashear upon Hastings' curves and the mounting provided by Warner and Swasey.

GOTHA: *Harzer*.—Reduction of previous observations. The director's time has been given almost entirely to lectures and to his theoretical investigations.

GREENWICH: *Christie.*—The regular work of the observatory has been continued much the same as in previous years, and in addition astrophotographic observations have grown to be a part of the routine, more especially the catalogue of guide stars for the photographic chart. A 9 inch Grubb photographic telescope has been presented to the observatory by Sir Henry Thompson and has been mounted on the Lassell equatorial as a photoheliograph. The erection of the new 36-foot dome, which is to cover the 28-inch refractor, was begun in December, 1892. A discussion of Greenwich observations from 1851 to the present time by Mr. Thackeray has furnished a very satisfactory confirmation of Mr. Chandler's doubly periodic variation of the latitude (in about 365 and 427 days, respectively). A successful longitude campaign has been carried on with Montreal, and the difference of longitude between Greenwich and Paris has been redetermined by English and French observers. Some additions to the equipment have been made and the details of an electric-light installation have been settled.

HAMBURG: *Rümker.*—Observations of comets, asteroids, and comparison stars; chronometer work for the German navy; meteorological observations, and time service.

HARVARD COLLEGE: *Pickering.*—With the meridian circle the observation of stars in the southern Durchmusterung zone (—9° 50′ to —14° 10′) has advanced toward completion. The 15 inch equatorial has been employed on observations partly photometric and partly micrometric, while the principal work done with the west equatorial has been the study by Argelander's method of the changes in the light of the variable stars of long period.

Photographic observations, provided for by the Henry Draper memorial, have been carried on continuously, generally throughout every clear night, and with the aid of three telescopes.

An attempt to secure a suitable location for the Boyden Fund observing station on Wilson's Peak, in southern California, proved unsuccessful, but an expedition sent out to Peru, under the direction of Prof. W. H. Pickering, left Cambridge in December, 1890, and established a station about 3 miles northwest of Arequipa, where a 13-inch equatorial was mounted and observations were commenced. The station is over 8,000 feet above sea level, and has a nearly cloudless sky during a large part of the year; the thermometer rarely falls below 40° F., and rarely goes above 70°. The brilliancy of the stars is most striking; stars of the 6.5 magnitude are picked out easily with the naked eye, the eleven Pleiades can be counted, and the Gegenschein can be readily seen any evening after 9 o'clock.

The Harvard Observatory time service, which had been in operation with but little interruption since 1856, was discontinued after March 31, 1892, having become financially unprofitable, by reason of the fact that time signals from the United States Naval Observatory were

offered to the public in Boston through the Western Union Telegraph Company at a lower rate than they could be furnished by the Harvard Observatory.

HATHORN (Saratoga Springs, N. Y.): *del Corral.*—Physical observations of Jupiter with a 6-inch telescope.

HAVERFORD COLLEGE: *Leavenworth.*—Work on stellar parallax; sun-spot observations.

HEIDELBERG: *Wolf.*—Stellar photography, photometric observations. Prof. Wolf has been very successful in the discovery of new asteroids by photography.

HERÉNY: *von Gothard.*—Spectroscopic researches; photography of nebulæ; observations of variable stars; meteorological observations; time service, and computations of asteroids.

HONGKONG: *Doberck.*—Time service; meteorological and magnetic observations.

IOWA UNIVERSITY: *Weld.*—A student's astronomical observatory has recently been established at the State University of Iowa, Iowa City, under the direction of Prof. L. G. Weld. The main building is 12 feet square, capped by a cylindrical turret in which is mounted a Grubb equatorial of 5 inches aperture, and 77½ inches focal length; a Würdemann transit of 1⅞ inches aperture and 24 inches focus is mounted in a wing 10 by 12 feet. Subsidiary apparatus consists of a 4-inch portable Fitz equatorial, clock, chronometer, and chronograph.

JACKSON (Mich.)—Small private observatory of Mr. U. W. Lawton.

JENA: *Knopf.*—The observatory was founded in 1812 by the Grand Duke of Saxe-Weimar. Observations of comets, occultations, phenomena of Jupiter's satellites, variable star observations; time service; meteorology. A new equatorial of 20 centimeters (7.9 inches) aperture and 3 meters (9.8 feet) has been installed.

KALOCSA: *Fényi.*—Solar and meteorological observations.

KENWOOD: *Hale.*—The Kenwood Physical Observatory, the private observatory of Prof. George E. Hale, had its inception in a spectroscopic laboratory erected in Chicago in the summer of 1888. The addition of a tower and wing during the winter of 1890-'91 brought the building to its present form, and it now includes a reception room, library, equatorial room, "slit room," "grating room," photographic dark room, general laboratory, and workshop. The grating room contains a 4-inch concave grating of 10 feet radius of curvature, mounted in the manner employed by Prof. Rowland. A shorter girder allows the use of a grating of only 5 feet radius in cases when the light source is too faint to admit of the highest dispersion. Sunlight is furnished by a heliostat on a pier some distance to the north of the building. Electrical power is supplied through a gas engine and storage battery and also from the main city wires.

The mounting of the equatorial was finished in March, 1891, by Warner and Swasey, and the excellent 12.2 inch object glass, figured

from Dr. Hastings's calculation, by Brashear, was in place and ready for use in April, 1891. The spectroscope is large, the objectives being alike and of 3¼ inches clear aperture and 42½ inches focus, corrected for work in the visual region. The grating is a 4-inch flat, in addition to which there is a 30° white flint prism. A second photographic objective of exactly the same aperture and focal length as the visual glass will be provided and a double tube will replace the single tube, the object glass being so supported that either one may be used on either tube.

The observatory was formally dedicated on June 15, 1891; it has been incorporated under the laws of the State of Illinois and its control is vested in a board of trustees. The plan of work includes a study of solar phenomena, with especial attention to spectroscopic investigations of the spots, chromosphere, and prominences. An interesting and well illustrated description of the observatory, together with an address delivered at the dedication by Prof. Young, is published in the Sidereal Messenger for August, 1891.

KIEL: *Krueger*.—"Centralstelle für astronomische Telegramme." Spectroscopic and photometric observations, observations of comets and asteroids and computations of orbits and ephemerides.

KÖNIGSBERG: *C. W. F. Peters*.—Meridian observations, heliometer measures of double stars, and for parallax; observations of comets and of the moon. Meteorology.

KREMSMÜNSTER: *Wagner*.—Observations of comets and sun spots. Time service, meteorological and magnetic observations.

LADD: *Upton*.—The Ladd observatory was formally presented to Brown University, Providence, R. I., by Governor Ladd on October 21, 1891. The building and equipment have cost nearly $30,000. The main part of the building is 43 by 27 feet, and the transit room 25 by 15 feet. The chief instrument is an equatorial of 12.2 inches aperture, objective by Brashear, and mounting by Saegmuller. It is one of three recently made by Mr. Brashear from the formulæ of Prof. C. S. Hastings. The mounting embodies several convenient devices. The spectroscope, which is of special excellence, is by Brashear.

The clock room is a chamber in the equatorial pier, and contains a Howard sidereal and a Molyneaux mean time clock. The other instruments are a 3 inch portable transit by Saegmuller; a smaller transit for students' use, a Warner and Swasey chronograph, several chronometers and sextants, a barograph, thermograph, and recording hygrometer by Richard Frères, a recording rain and snow gauge by Ferguson, and ordinary meteorological instruments. The observatory is designed primarily for the instruction of students, but also for research, and the equipment has been planned for a possible extension of the latter as the resources of the observatory may allow. The director is Prof. Winslow Upton.

LEIPZIG: *H. Bruns*.—Parallax measures of stars with large proper

motions, observations of planets and asteroids. Zone work +5° to +10°, and +10° to +15°; triangulation of trapezium of Orion. Time service and meteorological observations.

LICK: *Holden.*—A new building has been erected to cover the Willard photographic lens (aperture 5.9 inches, focal length 31 inches), and its mounting by Brashear, presented by Hon. C. F. Crocker. The dome is 10 feet in diameter, and attached to it is a photographic dark room about 10 by 11 feet.

A graduate school of astronomy has been established at the Lick Observatory as a part of the graduate system of the University of California, and a special fund established by Mrs. Phebe Hearst is in part available for the expenses of advanced students elected fellows by the regents.

Barnard's discovery of a fifth satellite of Jupiter with the 36-inch refractor has been referred to elsewhere.

LIÈGE: *Folie.*—This observatory is attached to the Royal Observatory at Brussels, and its observations are published in the Brussels volumes. Much excellent theoretial work has been done by M. de Ball while awaiting repairs to the meridian circle.

LIVERPOOL: *Plummer.*—Time service, chronometers, meteorological observations. The 8-inch equatorial has been used in the systematic observation of comets.

LUND: *Folke Engström.*—Work on zone +35° to +40°.

MCCORMICK: *Stone.*—Prof. Stone has published a continuation of the Bonn Durchmusterung, upon which he has been engaged for a number of years.

MADRAS: *Smith.*—Mr. C. Michie Smith, since the death of Mr. Pogson, has been chiefly engaged in pushing forward the publication of observations of earlier years. Observations other than those required for the efficient maintenance of the time service have been entirely subordinated to the work of publication. Two volumes of the valuable *Madras Meridian Circle Observations* have been issued.

MELBOURNE: *Ellery.*—Meridian circle work has been continued. The photographic telescope was mounted in January, 1891, and considerable progress has been made towards the photographic catalogue. Meteorological and magnetic observations, time service, and chronometer rating have been kept up, but the observatory has been seriously crippled by the reduction of its appropriations, necessitating the retirement of two assistants.

MILAN: *Schiaparelli.*—Measurements of double stars; preparations for a catalogue of 1,100 stars, zone +2° to +6° observed from 1860 to 1872. Longitude work, time service, and magnetic observations.

MISSISSIPPI UNIVERSITY: *Fulton.*—Under date of July 6, 1891, it was reported (Sid. Mess., No. 97) that a "twin equatorial" (a 15-inch visual telescope and a 9-inch photographic telescope side by side on the same mounting) was under construction by Grubb.

MOUNT HOLYOKE (South Hadley, Mass.)—Sun-spot observations.

MOUNT ROSA.—A small observatory is in course of construction on Mount Rosa, 15,000 feet above sea level, consisting of a wooden hut 10 by 30 feet.

MUNICH: *Seeliger.*—A new Repsold 6 inch meridian circle was mounted in July, 1891. Observations of comets and of Saturn with the 10½ inch refractor; investigations of personal equation dependent on the magnitudes of stars; longitude work, meteorological observations.

NATAL.—Observations of the Moon's position and of Mars.

O'GYALLA: *Konkoly.*—Observations of sun spots, drawings of Jupiter; a few spectroscopic observations and some photographic experiments. Much time has been spent in the reorganization of the Government Meteorological Bureau.

OXFORD (University).—The series of observations for determining by photography the parallax of about 30 stars chiefly of the second magnitude has been completed and the results published. Much time has been spent in the preparation of the new instruments to be used on the international chart of the heavens, and a considerable number of plates comprised in the zone assigned to Oxford have been completed. Experimental work has also been done for the committee in charge of the international chart.

A convenient observatory has been erected contiguous to the main building for the exclusive use of university students. This observatory is furnished with two small transit circles, three telescopes, one of which is a reflector of 15 inches aperture, and subsidiary apparatus.

PARIS: *Tisserand.*—In the report for 1891 the director stated that the Gambey circle had been applied to the investigation of the latitude and the question of its variation; observations to determine the constant of aberration were completed, and besides the usual planetary and cometary observations, a considerable number of measurements of double stars and micrometric measures of nebulæ were made.

Photographic work upon the great chart and upon the moon has been continued, and the newly organized department of spectroscopy has obtained interesting results under M. Deslandres.

The report for 1892 contains a tribute to Admiral Mouchez, the late director, an account of gratifying progress in the photographic and spectroscopic work, and with the equatorial coudé. A "Bureau des Mesures des Clichés du Catalogue" has been organized, with Mlle. Klumpke at its head.

POTSDAM: *Vogel.*—The spectroscopic determination of the motion of stars in the line of sight to which Dr. Vogel has given especial attention has been continued, and many of the results have been published. Dr. Scheiner has worked upon stellar spectra and the spectra of solar prominences. Prof. Müller and Dr. Kempf have completed their observations for a photometric Durchmusterung, and Prof. Müller his long series of photometric observations of the planets. Dr. Lohse and Prof.

Spoerer have been engaged in photographic and visual observations of the sun.

PRAGUE: *Safarik.*—Variable stars.

PRAGUE (University): *Weinek.*—Drawings of the moon. Determination of latitude, observations of Jupiter's satellites, time service, magnetic and meteorological observations.

PROVIDENCE (R. I.).—*See* Ladd.

RADCLIFFE (Oxford): *Stone.*—Work on the general catalogue of 6,350 stars for 1890; meridian observations of the sun and moon. Observations of comets, double stars, and occultations. Meteorology.

ROME.—The first fascicule of the publications of the new Vatican observatory contains the interesting Papal Brief founding the observatory, an historical introduction, and two papers on astronomical photography, to which the observatory is to be for the present devoted.

ROUSDON (Lyme Regis): *Peek.*—Variable stars; time service.

SAN DIEGO (Cal.)—Mrs. Proctor, widow of the late R. A. Proctor, proposes to erect an observatory at San Diego as a memorial to her husband; an 18-inch object glass has been ordered.

SAN FERNANDO: *Viniegra.*—Capt. J. Viniegra has been appointed director, to succeed Capt. Pujazon.

SMITH (Beloit, Wis.): *Bacon.*—Sun-spot observations, etc.

STONYHURST: *Sidgreaves.*—Photography of the solar spectrum and of stellar spectra; drawings of sun spots and measures of the chromosphere and prominences. A new 15-inch refractor has been purchased with the fund raised to the memory of the late Father Perry.

STRASBURG: *Becker.*—The meridian circle has been used in observing the zone $-2°$ to $-6°$, and also the sun, moon, and planets. Some defects in the construction of the altazimuth were remedied and the instrument was used in a careful series of observations for the determination of the variation of latitude, beginning in May, 1891, and ending in March, 1892.

SYDNEY.—Transit-circle work, observations of double stars and of comets; photographic work for the international chart, photographs of comets and of Mars. Weather-chart service.

TEMPLE (Rugby): Double stars; nebulæ photography.

TOULOUSE: *Bigourdan.*—From an account of the history of the observatory by M. Bigourdan it appears that it was originally established in 1729 on one of the towers of the rampart of the town. Garipuy made some observations there, but afterwards erected an observatory on his own house and superseded it by a larger and more commodious one in 1770. Darquier assisted him for a time, but afterwards erected an observatory of his own. Vidal had commenced his astronomical work at the observatory of Garipuy, which, however, became the property of the states of Languedoc after the death of the founder in 1782. Vidal retired in 1807, and, after several attempts to improve the observatory, it was decided in 1840 to erect a new one at the ex

tremity of the town. The buildings were commenced the following year, but it was not until the end of 1846 that they received their instrumental equipment. Garipuy's observatory was then abandoned.

UNDERWOOD (Appleton, Wis.): *L. W. Underwood.*—The Underwood observatory in connection with Lawrence University at Appleton, Wis., was equipped at the opening of the college year of 1892–'93. The outfit consists of a 10 inch Clark equatorial, 4 inch meridian circle, mean-time and sidereal clocks, chronometer, and chronograph. A local time service has been established.

UNITED STATES NAVAL OBSERVATORY: *McNair.*—At the time of the last report of the Superintendent, September 29, 1892, the new buildings were not ready for occupancy. The usual routine observations have been somewhat interrupted by preparations made for the removal of the instruments to the new site, advantage being taken of the interruption of observations to advance the reductions of previous years.

Prof. Asaph Hall was retired by law from active service as a staff officer of the Navy on October 15, 1891.

UPPER TULSE HILL: *Huggins.*—Visual and photographic observations of Nova Aurigæ (1892).

UPSALA: *Dunér.*—Variable stars; stellar photography. A new photographic refractor of 33 centimeters (13 inches) objective has been under construction, and has necessitated some alterations in the building. Time service.

VASSAR: *Miss Whitney.*—Sun-spot observations, observations of comets, etc.

WESTMEATH: *Wilson.*—The 2-foot Grubb reflector has been remounted and used for stellar photography. Some photographs of Jupiter have been taken with a photographic photometer, to determine the relative albedo of the planet and his moons.

WINDSOR: *Tebbutt.*—Observations of comets, double stars, occultations, and the phenomena of Jupiter's satellites.

WOLSINGHAM: *Espin.*—Spectroscopic zone work; double stars. A number of new variable stars have been discovered. Meteorological observations.

YALE.—Dr. Elkin's heliometer work constitutes the chief astronomical activity. In 1891 the series of observations to determine the parallaxes of the first magnitude stars of the northern hemisphere was completed. Observations have also been made of comparison stars for Victoria, and the computations on the Iris series in 1888 have been carried forward chiefly by Miss Palmer. Observations of comets and asteroids were made by Mr. Chase with the 8-inch Reed equatorial.

From July, 1891, to January, 1892, the heliometer was devoted to a series of measures on the satellites of Jupiter for the determination of their orbits, and the mass of the planet. After the completion of this work Dr. Chase completed a triangulation of the principal stars in Coma Berenices. A series of measures of Algol has been made to test

the theory of a sensible orbital motion of the bright component, and the theoretical parallax, suggested by Mr. Chandler.

YERKES (University of Chicago): *Hale.*—Through the munificence of Mr. Charles J. Yerkes, of Chicago, the University of Chicago is to have an astronomical observatory of the first class. No definite limit has been assigned to the expenditure contemplated, but it is intimated that the equipment shall be equal to any in existence. The principal instrument will be a 40-inch refractor, the disks for which were made some years since for the University of Southern California.

The remainder of the equipment is still undetermined, but it will probably include a 16-inch refractor, 12-inch "twin" equatorial with visual and photographic objectives, 6-inch meridian circle, and 20-inch siderostat.

ZÜRICH: *R. Wolf.*—Sun-spot observations; observations for determining the variation of latitude; time service.

ASTRONOMICAL INSTRUMENTS.

Brashear-Hastings objectives.—Three large object glasses recently made by Brashear are of more than ordinary interest, as they have been ground by Prof. Hastings' formula. They are the 16-inch of the Goodsell Observatory, the 12.2 of the Ladd Observatory, and the 12-inch of the Kenwood Physical Observatory. The crown glass was obtained from Mantois, of Paris, and the flint from the optical works at Jena, Germany.

A new instrument has been devised by A. Beck, called a "Nadir-Instrument," for the determination of time and latitude by observation of the transits of stars over a circle whose pole is the zenith. The instrument is adjusted for a circle of 60° zenith distance.

To amateurs a series of articles on the "Adjustment of a small Equatorial," in the Journal of the British Astronomical Association (February, 1892), by Mr. Maunder, will undoubtedly prove of interest and value.

MISCELLANEOUS.

Prizes.—The Lalande prize of the Paris Academy for 1891 was awarded to M. G. Bigourdan for the work he has undertaken and partly carried out, of micrometrically measuring all the known nebulæ, about six thousand in number, observable at Paris; this will be a first step to obtaining some knowledge of their proper motions, and ultimately, perhaps, of their distances from the sun. No memoir was presented to the Academy on the special subject proposed for the Damoiseau prize, "To perfect the theory of the inequalities of long periods caused by the planets in the motion of the moon." It was, therefore, proposed again for 1892, and its value fixed at 4,000 francs. Prizes were, however, adjudged, for their planetary and cometary inves-

tigations, to MM. Gaillot, Callandreau, and Schulhof. The Janssen prize was awarded to M. Rayet, for his spectroscopic work. This prize is awarded annually for the first seven years after its foundation (1887), and becomes biennial in 1894.

The Lalande prize of the French Academy of Sciences was awarded on December 19, 1892, to Mr. E. E. Barnard for his astronomical discoveries, especially the discovery of the fifth satellite of Jupiter, and to Prof. Max Wolf for his work in astronomical photography, especially in the discovery of asteroids. The Damoiseau prize to MM. Radau and Leveau; the Valz prize to M. Puiseaux for his work on the theory of astronomical instruments and the constant of aberration; the Janssen prize to M. Tacchini for his work on the solar spectrum.

The Donohoe Comet Medals of the Astronomical Society of the Pacific.—The following amended rules for the bestowal of the medal took effect on February 26, 1891.

I. A medal of bronze is established as a perpetual foundation to be given for the discovery of comets, as follows:

The medal is to bear on the obverse side the effigy of a bright comet among stars, with the legend "ASTRONOMICAL SOCIETY OF THE PACIFIC" around the border, and on the reverse the inscription, "THIS MEDAL, FOUNDED IN 1890 BY JOSEPH A. DONOHOE, IS PRESENTED TO ——— (the name of the discoverer) TO COMMEMORATE THE DISCOVERY OF A COMET ON ——— (the date)."

It is to be understood that this medal is intended solely as a recognition of merit, and not as a reward.

II. The medal will be given to the actual discoverer of any unexpected comet.

III. The discoverer is to make his discovery known in the usual way, and, in order to simplify the work of the committee, which, in certain cases may be called upon to consider the merits of several independent discoveries of the same object, he should also address a letter to the Director of the Lick Observatory, which should state the exact time of the discovery, the position of the comet, the direction of its motion (when this can be determined), and the physical appearance of the object.

No application for the bestowal of the medal is required. The letters received from discoverers of comets will be preserved in the records of the Lick Observatory. Cable telegrams to the Lick Observatory are to be addressed to "Astronomer, San Francisco."

IV. All communications will be referred to a committee consisting of the Director of the Lick Observatory, *ex officio*, and of two other persons, members of the Astronomical Society of the Pacific, who are to be annually appointed by the Board of Directors. The decisions of this committee are to be final upon all points relating to the award of the medal. The committee will print an annual statement of its operations in the publications of the society.

Under ordinary circumstances the comet medal will be awarded within two months after the date of the discovery. In cases of doubt a longer period may elapse. The medal will not be awarded (unless under the most exceptional circumstances) for the discovery of a comet until enough observations are secured (by the discoverer or by others) to permit the calculation and verification of its orbit.

V. This medal is to be a perpetual foundation from and after January 1, 1890.

The fourth award of the Donohoe medal was made to Dr. R. Spitaler, assistant in the Imperial Observatory of Vienna, for his discovery of a comet "in the morning hours" of November 16, 1890. This was the first comet discovered by Dr. Spitaler.

The fifth award was made to Prof. T. Zona, adjunct astronomer in the Royal Observatory of Palermo, for his discovery of a comet at $9^h\ 31^m$, Greenwich mean time, November 15, 1890. Also, his first discovery of a comet.

The sixth award was made to Mr. E. E. Barnard, astronomer of the Lick Observatory, for his discovery of a comet at 16 hours, Greenwich mean time, on March 29, 1891. This was the fifteenth comet discovered by Mr. Barnard.

The seventh award was also made to Mr. Barnard for a comet discovered at $0^h\ 55^m$, Greenwich mean time, on October 3, 1891.

The eigth award was made to Dr. Lewis Swift for his discovery of an unexpected comet on March 6, 1892.

The ninth award was made to Mr. W. F. Denning, of Bristol, England, for his comet of March 18, 1892.

The tenth award to Mr. W. R. Brooks, of the Smith Observatory, Geneva, New York, for a comet on August 28, 1892.

The eleventh award was made to Mr. E. E. Barnard for his discovery by photography of an unexpected comet on October 12, 1892, at Mount Hamilton.

The twelfth award was made to Mr. Edwin Holmes, of London, England, for his comet of November 6, 1892.

The thirteenth award to Mr. W. R. Brooks for his comet on November 19, 1892.

The Acton prize.—Once in seven years the Acton prize of £100 is awarded to the person whose scientific writings have been most serviceable to the cause of natural religion. The last prize was adjudged to Prof. G. Stokes, of Cambridge University. The recipient in 1892 was Miss Agnes Clerke, author of the "History of Astronomy in the Nineteenth Century;" of the "System of the Stars;" and of "Studies in Homer."

The Bruce fund.—The fund of \$6,000 placed by Miss Bruce in Prof. Pickering's hands to be used in aid of astronomical work, has been applied as follows: To Prof. Newcomb, for a discussion of the contact observations of Venus during the transits of 1874 and 1882; Dr. Plass-

mann, printing observations of meteors and of variable stars; Astronomische Gesellschaft, construction of tables for the computation of the absolute perturbations of the asteroids by Gyldéns method; International Geodetic Commission, dispatch of a party to the Sandwich Islands for a study of the variations of latitude; Mr. H. H. Turner, computation of tables for reductions of star places; Prof. E. S. Holden, reduction of meridian observations of Struve stars; Prof. H. A. Rowland, identification of metals in the solar spectrum; Dr. L. Struve, reduction of the occultations observed during the eclipse of January 28, 1888.

It may not be out of place here to note that a legacy of 100,000 francs ($20,000) has been left by an old lady of Pau to the Institute of France, as a reward for the person of any nationality who shall, within the next ten years, succeed in communicating with the inhabitants of some other celestial body. Apropos of this legacy, Flammarion has written an interesting article in L'Astronomie as to the possibility of our ever being able to accomplish communication with our neighbors.

The Danish Academy of Sciences and Letters has awarded a gold medal to Baron E. von Haerdtl, of Innspruck, for his memoir on a case of the problem of three bodies proposed by the Acadamy in 1889.

Astronomy and astro-physics.—With its one hundred and first number, the *Sidereal Messenger*, which has been edited by Prof. W. W. Payne, at Northfield, Minn., since 1882, takes a new name, and is enlarged, so that a considerable portion of each number is devoted, under the able editorship of Prof. G. E. Hale, of Chicago University, to what is now known as astro-physics. Prof. Payne continues as senior editor in "General Astronomy," assisted by Prof. H. C. Wilson. The bibliographer will note that, though the journal has a new name, the volume and current number are continued from the *Sidereal Messenger*; thus the initial number of Astronomy and Astro-physics is "Number 101," forming part of "Volume XI."

It is stated that there are to be erected in Berlin three hundred "Urania pillars." These pillars will be about 18 feet high, made of cast iron, and will each contain a clock, meteorological instruments, weather charts, astronomical and geographical announcements, and also, as in the streets of Paris, a plan of the neighboring streets in enlarged form to enable strangers to find their way. The instruments are to be regulated from the observatory.

A star atlas by Herr Jacob Messer, of St. Petersburg, the page being about 4½ inches by 8¼ inches, will be found extremely convenient for amateur observers who do not care to burden themselves with the larger works. It contains all the stars visible to the naked eye (first to sixth magnitudes, inclusive), from the north pole down to 35° south declination, together with a selection of the most interesting double stars, variables, nebulæ, clusters, etc.

Much interesting light has been thrown of late on Babylonian astronomy by Fathers Epping and Strassmaier. A series of lunar and planetary observations has recently been found in the cuneiform tablets of the British Museum, and among others an observation of a lunar eclipse, one of the nine used by Ptolemy in his Almagest. Another work of the same authors shows that the Babylonians were able to predict the rising and setting of the moon, and the hour and magnitude of an eclipse.

Mr. A. M. W. Downing, superintendent of the computations at the Royal Observatory, Greenwich, was appointed to succeed Dr. Hind, who retired from the position of superintendent of the British Nautical Almanac office on January 1, 1892.

The Astronomische Gesellschaft held its fourteenth biennial meeting at Munich August 5–7, under the presidency of M. Gyldén. The society numbers 318 members.

A new astronomical society.—An association was formed in Berlin, in 1891, called the "Union of Friends of Astronomy and Cosmical Physics," for the purpose of securing co-operation in the study of these sciences in the countries of central Europe. The strength of the new society is perhaps best indicated by the names of its officers, Prof. Lehmann-Filhés being president, and Herrn Förster, M. W. Meyer, Plassmann, Jesse, Weinstein, and Reimann the presidents of its six sections.

The question of the ownership of an aerolite has been referred for settlement to the courts, and the decision reached is of some interest. On May 2, 1890, an aerolite weighing 66 pounds fell on the land of John Goddard, in Winnebago County, Iowa. It was dug up by Peter Hoagland, carried to his house, and sold for $105. Goddard claimed it as it had fallen on his land, while Hoagland claimed it as he discovered it and as it fell from heaven. In the suit that resulted the court held that the stone became part of the soil on which it fell, and that Hoagland had no right to remove it. The defense claimed that whatever was movable and found on the surface of the earth unclaimed by any owner was supposed to be abandoned by the proprietor.

NECROLOGY OF ASTRONOMERS, 1891–92.

ADAMS (JOHN COUCH). Born near Launceston, Cornwall, June 5, 1819; died at Cambridge, England, January 21, 1892.

AIRY (GEORGE BIDDELL). Born at Alnwick, July 27, 1801; died at Greenwich, January 2, 1892.

BRÜNNOW (FRANZ FRIEDRICH ERNST). Born at Berlin, November 18, 1821; died at Heidelberg, August 20, 1891.

CLARK (GEORGE BASSETT). Born at ———, February 14, 1827; died at Cambridgeport, December 30, 1891.

DE GASPARIS (ANNIBALE). Born at Bugnæa, November 9, 1819; died at Naples, March 21, 1891.

GAUTIER (EMILE). Born at Geneva, April 18, 1822; died at Geneva, February 25, 1891.

GRANT (ROBERT). Born at Grantown-on-Sprey, June 17, 1814; died at Grantown, October 24, 1892.

HARTNUP (JOHN). Born in London, 1811; died at Liverpool, April 21, 1892.

VON HAYNALD (LUDWIG). Born at Szécsény, 1816; died at Kalocsa, July 4, 1891.

KLEIBER (JOSEPH). Born at St. Petersburg, December 15, 1863; died at Nice, February 12, 1892.

MOUCHEZ (AMÉDÉE ERNEST BARTHÉLEMY). Born at Madrid, August 24, 1821; died at Wissons, June 29, 1892.

POGSON (NORMAN ROBERT). Born at Nottingham, March 23, 1829; died at Madras, June 23, 1891.

RUTHERFURD (LEWIS MORRIS). Born at Morrisania, November 25, 1816; died May, 30, 1892.

SCHÖNFELD (EDUARD). Born at Hildburghausen, December 22, 1828; died at Bonn, May 1, 1891,

SEYDLER (AUGUST). Born at Senftenberg, June 1, 1849; died at Prag, June 22, 1891.

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The following bibliography or index catalogue is arranged upon the plan adopted in the review of astronomy for 1886, thus making this series of indexes complete from that year to 1892, except for the year 1890, an index for which was published in the *Sidereal Messenger* for 1891 (vol. 10, pp. 84, 356).

The principal books, memoirs, and journal articles published in 1891 and 1892 that have come under the compiler's notice are here included, and there are also a few titles that belong to earlier years but were not found in time to insert in previous lists. References to series of observations, preliminary orbits of comets and asteroids, reviews, etc., are omitted, and to condense it into reasonable limits the bibliography has not been made exhaustive even to the extent of printing all titles that were originally collected.

The subject headings are in alphabetical order, with a subarrangement by authors. The references to periodicals are by volume and page separated by a colon: thus: Obsry. 15:173–89 indicates volume 15, pages 173 to 189, of *The Observatory.*

The following is a list of the principal periodicals examined:

American Journal of Science, vols. 141–144.
Astronomical Journal, Nos. 233–283.
Astronomische Nachrichten, Nos. 3010–3139.
L'Astronomie, vols. 10 and 11.
Astronomy and Astrophysics, vol. 11.
Bulletin Astronomique, vols. 8 and 9.
Comptes Rendus, vols. 112, 113, 114, 115.
Journal of the British Astronomical Association.
Monthly Notices of the Royal Astronomical Society, vols. 51, No. 3, to vol. 52, No. 9.
The Observatory, vols. 14, 15.
Publications of the Astronomical Society of the Pacific, Nos. 13 to 26.
Sidereal Messenger, vol. 10.
Vierteljahrsschrift der Astronomischen Gesellschaft, 26.–27. Jahrg.

ABBREVIATIONS.

Abstr. = Abstract.
Am. = American.
Bd. = Band.
d. = di, der, del, etc.
ed. = edition.
Hft. = Heft.
hrsg. = herausgegeben.
il. = illustrated.
j., jour. = journal.
k. k. = kaiserlich-königlich.
Lfg. = Lieferung.
n. d. = no date.
n. p. = no place of publication.
n. F. = neue Folge.
n. s. = new series.
Not. = Notices.
Obsry. = Observatory.
p. = page.
pl. = plates.
portr. = portraits.
pt. = part.
r. = reale.
Rev. = Review.
s. = series.
sc. = science, scientific.
vol. = volume.

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